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COMMERCE ENERGY BIOGAS/PV MINI-GRID RENEWABLE SOURCES PROGRAM

Task 3.1.6 MONITORING, REPORTING, AND VERIFICATION PROTOCOL FOR THE INLAND EMPIRE UTILITY AGENCY ANAEROBIC DIGESTER

PIER FINAL PROJECT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

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Executive Summary

This document contains the Monitoring, Reporting, and Verification Protocol for the operation of the Inland Empire Utilities Agency anaerobic digesters. The California Energy Commission, through its Public Interest Energy Research Program, provided financial and technical support for this effort. The Environmental Resources Trust, Inc. developed this protocol in conjunction with Eastern Research Group who prepared the baseline analysis.

The Monitoring, Reporting, and Verification protocol is an essential tool that guides and standardizes the process of gathering monitoring data, calculating annual emissions and emission reductions, and reporting results to emission registries and stakeholders. The protocol documents the assumptions, data sources and methodologies that the Energy Research Program and Eastern Research Group used to calculate emissions and explains the process used to verify the results. This version of the Monitoring, Reporting, and Verification Protocol is an update and expansion, based on peer review comments and user testing, of earlier draft versions. This expanded Monitoring, Reporting, and Verification Protocol addresses explicitly the certification of renewable energy from the digester operations. Energy Research Group is grateful to the Energy Commission's Public Interest Energy Research Program and staff for their interest in, and assistance with, this project.

Incorporated into an associated spreadsheet, referred to as the Inland Empire Utilities Agency Digesters Model, this Monitoring, Reporting, and Verification Protocol outlines and describes the entire methodological approach. The Inland Empire Utilities Agency Digester Model is a multimedia environmental analysis tool, providing a stand-alone, fully documented platform to track a wide variety of environmental data in a comprehensive integrated package. Greenhouse gas and criteria pollutant emissions, ammonia releases, and surface water run-off are among the impacts the tool addresses.

Environmental Resources Trust audited and verified the results for 2003 and 2004. The Appendices include summary tables of emissions and reductions and an Environmental Resources Trust-issued 2004 verification statement.

A. Introduction

Inland Empire Utilities Agency (IEUA) is a municipal water district, serving the region for over 50 years. IEUA's mission is to supply imported drinking water and recycled water, collect, treat and dispose of wastewater, and provide utility-related services to the 7 communities and 700,000 residents in their service territory, including the local dairy operations. Dairy farms are California's largest agricultural sector and dairy manure is one of the most severe sources of air and water pollution in the Chino Basin as well as the Central Valley.

IEUA developed an Organics Management Strategy program to protect the Chino Groundwater Basin from infiltration of salts, nutrients and pathogens generated by dairies and to reduce future costs of removing contaminants from the groundwater. Stakeholders involved in the planning and decision- making process included the surrounding public, regulatory officials, elected representatives, environmental organizations, and the IEUA's member communities. An important first step for the implementation of the Organics Management Strategy was the development of a manure anaerobic digestion demonstration projects located at the IEUA Regional Plant Numbers 1 (RP-1) and 5 (RP-5). Inland Empire Utilities Agency operates these state-of-the-art anaerobic digester facilities, constructed in a public-private partnership consisting of IEUA, US Department of Agriculture, US Department of Energy, the Milk Producers Council, the California Energy Commission, and Synagro Technologies. The Environmental Resources Trust, Inc. (ERT) developed this monitoring, reporting and verification (MRV) protocol with assistance from Eastern Research Group (ERG).

The California Energy Commission (CEC) under the Public Interest Energy Research (PIER) program expressed interest in developing this protocol as part of an effort to quantify the full environmental impacts, and environmental and economic benefits, of the IEUA digester project. Further, this protocol can serve as a model for monitoring, reporting, and verifying emissions and emission reductions from other digester projects. The MRV protocol guides the process of gathering monitoring data, calculating annual emissions and emission reductions, and reporting results to emission registries and stakeholders. The protocol specifies what data IEUA will collect, and documents the assumptions, calculations, reviews, and other assessment procedures that ERT and ERG use to calculate emissions and verify the results. This version of the MRV Protocol is an update and expansion of earlier versions, based on peer review comments and user testing. This expanded MRV Protocol addresses explicitly the certification of renewable energy from the digester operations. Others who use this protocol as a model should check to see if emission factors have been updated, and use the most current emission factors.

Full and accurate measurement and assessment of digester performance and related manure management issues will accelerate the development of verified and tradable emission reductions and renewable energy certificates resulting from digester activity, and will contribute to their commercial viability in their respective emerging markets within the agricultural sector. The products and tools developed in this project will be made readily available to encourage the expanded use of anaerobic digesters to address manure waste management as well as other national environmental and energy objectives.

Protocol Objectives

The ultimate objective is that by following these guidelines a "true and fair" representation of the project's net direct emissions performance—which can be audited—will result. This Protocol addresses the methodology, data collection, data quality control, and data preservation issues related to the monitoring, reporting, and verifying of greenhouse gas and criteria pollutant emission reductions from the operation of an anaerobic digester project accepting manure from dairy operations.

In order to be verified, emission reductions must meet the following criteria:

- There must be a project activity that results in a reduction of direct emissions within the project's boundaries, such as changes in equipment, technologies, processes, or operations.
- Emission reductions must be quantifiable by acceptable, transparent, and replicable measurement and calculation tools and techniques. Raw data must be available to verify measurements, and calculations and statistical information provided to support the level of certainty/significance of the data. Baseline emissions determination must be explained and specified. The actual reduction beyond the baseline emission level must be specified.
- Emission reductions must be additional (i.e., surplus) to emission reductions that may be required by existing regulatory requirements.
- Ownership of the emission reductions must be clearly demonstrable by virtue of established ownership of relevant emitting facilities or lands, or by written agreement between the project developer and the owner or operator of facilities or lands.

Given these criteria, this MRV protocol and report shall:

- Define organizational and operation boundaries
- Identify the owners of the relevant facilities and lands where reductions occur and/or clearly establish ownership of the emission reductions
- Identify emissions sources
- Address issues of additionality and leakage
- Specify a project baseline against which emission reductions will be determined
- Specify monitoring and data collection techniques and procedures
- Specify emission factors & calculation methods, where applicable
- Identify supporting data for emissions quantification
- Describe data management and quality control procedures
- Specify reporting and documentation requirements, including frequency
- Address uncertainty

- Describe procedures for verification and registration of emission reductions
- Include an attestation statement by project operators

Applicability

This guideline is specifically applicable to greenhouse gas, ammonia, and criteria pollutant emission reductions resulting from operation of anaerobic digester projects where:

- The digester is fed in whole, or in part, with manure collected from dairy operations,
- The biogas generated is collected and flared, or
- The biogas generated is collected and used to generate electricity (or heat), but no emission reductions are claimed for displacing or avoiding electricity generation from other sources.

Periodic Reviews and Revisions

Environmental Resources Trust, Inc. (ERT) may require revisions to this Protocol to ensure that the monitoring, reporting, and verification system adequately addresses changes in the project's activities. Emission factors will be updated as new factors are issued by the US Environmental Protection Agency or the Intergovernmental Panel on Climate

An annual emissions report should be submitted by IEUA to ERT and will be subject to an annual review. As a part of this review, ERT will:

- Review the report and prepare adjustments or corrections
- Verify the data by applying audit-sampling methods
- Register verified emission reductions in the GHG Registry℠

This MRV Guideline also specifies the frequency of other MRV activities.

B. General description of project activity

The digesters at IEUA operate as a centralized manure management facility, as contrasted with on-farm digester projects. The digesters are currently processing manure collected from ten dairy farms in the Chino Basin, and future plans for expansion will increase the service area. A summary of the ten participating dairies is included in the Appendices to this report.

Figure 1 shows a typical corral at a participating dairy in Chino Basin. The cattle feed on a concrete feed lane and manure deposited on the concrete surface can be easily dry collected for transport to the IEUA digester facility.

Figure 2 shows a "honey vac" tanker truck used to collect fresh manure from the daily feedlot.

Fresh manure is removed daily from the dairy production areas and corrals and transported to the digester facilities. In some cases the manure is transported in larger 25 ton trucks.

Figure 3 shows manure being deposited into the digester mixing tanks.

The treatment process consists of an anaerobic digester (see cover photo depicting the RP-5 digester cover plate. The digester itself is below grade) for the destruction of organic material and the production of methane gas.

Figure 4 shows the biogas pipelines off the digester manifold leading into one of two onsite electric generators.

This renewable energy source currently delivers a 9 MW power supply to the reverse osmosis desalter unit used to recharge the groundwater, completing a closed loop system of dairy waste to energy to groundwater cleanup.

Figure 5 shows the reverse osmosis tubes used to desalt the groundwater prior to reinjection in the aquifer, while the filtrate is discharged to a brine line before being ocean discharged in accordance with all permits.

Figure 6. The biosolids produced are dewatered and conveyed to a composting facility.

Identification of boundary conditions

The project boundaries include all the operations associated with manure digesters at RP-1 and RP-5. The project methodology covers direct emissions from sources owned and operated by IEUA. Although the generation of renewable energy at IEUA will displace demand for fossil fuel derived electricity, no reductions attributable to displaced emissions from offsite power plants are included in this protocol. The project boundaries also include the local dairies to the extent that GHG and ammonia emissions from the dairies are reduced due to the collection, removal and processing of manure on a daily basis. Note that the baseline methodology addresses indirect pathways for N_2O emissions, in accordance with IPCC guidelines. These “indirect” pathways for N_2O emissions are included in this Protocol since they are a direct result of manure management systems including agricultural field application and are not included in any other entities’ emission inventory.

Identification of emission points and pathways

The emission points for the project are described in detail in the IEUA Digester Model developed under this effort and summarized in the Appendices. Key on-site emission sources include:
- flare and engine emissions at RP-1 and RP-5
- boiler emissions from RP-1
- flare emissions from both RP-1 and RP-5, and
- water heater emissions from RP-5

The Waukesha engines used at RP-1 and RP-5 are the largest sources of air emissions in the project and are used to generate electricity to power the reverse osmosis systems at the dewatering unit. In order to accurately quantify the emissions from these sources, actual on-site test data was evaluated. The source testing conducted at IEUA was reviewed by engineers at the South Coast Air Quality Management District (SCAQMD) and incorporated into the operating permits for these units. The site-specific emission factors developed and used to report to SCAQMD were compared to national average factors compiled in USEPA AP-42 and were determined to be the best available emissions factors for this project.

In addition, emission results obtained using SCAQMD sulfur dioxide emission factors were compared to results obtained from a detailed sulfur balance using concentration data and flow rates. The results were in close agreement (differing by less than 0.1 tons of SO_2 per year). In accordance with our project’s data quality objectives, and in order to minimize (as much as technically feasible) the data collection burdens, the approach outlined herein uses the approved SCAQMD SO_2 emission factors.

All emission factors are documented and summarized in the Appendices.

Key emission pathways from the dairies are illustrated in the flowing flow charts. An exhaustive list of individual sources, emission estimates, and key emission drivers are listed in the spreadsheet model. Off-site emission sources include
- dairy feed lots
- vehicle emissions from trucking manure
- lands where manure or composted material is spread

Figure 7. 2003 Methane (CH_4) Emissions in IEUA Basecase: Southern California Dairies – No Manure to Digestion

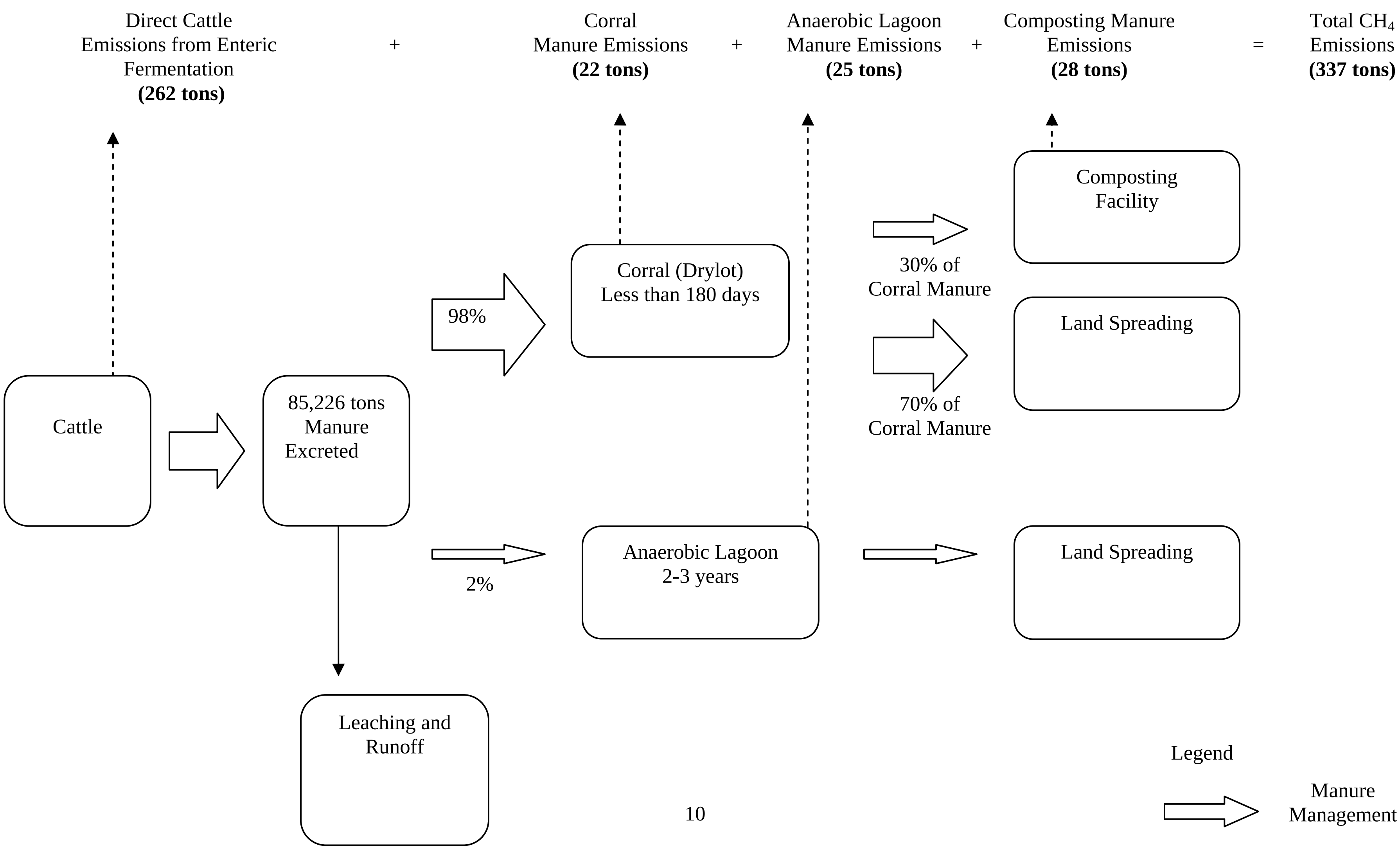
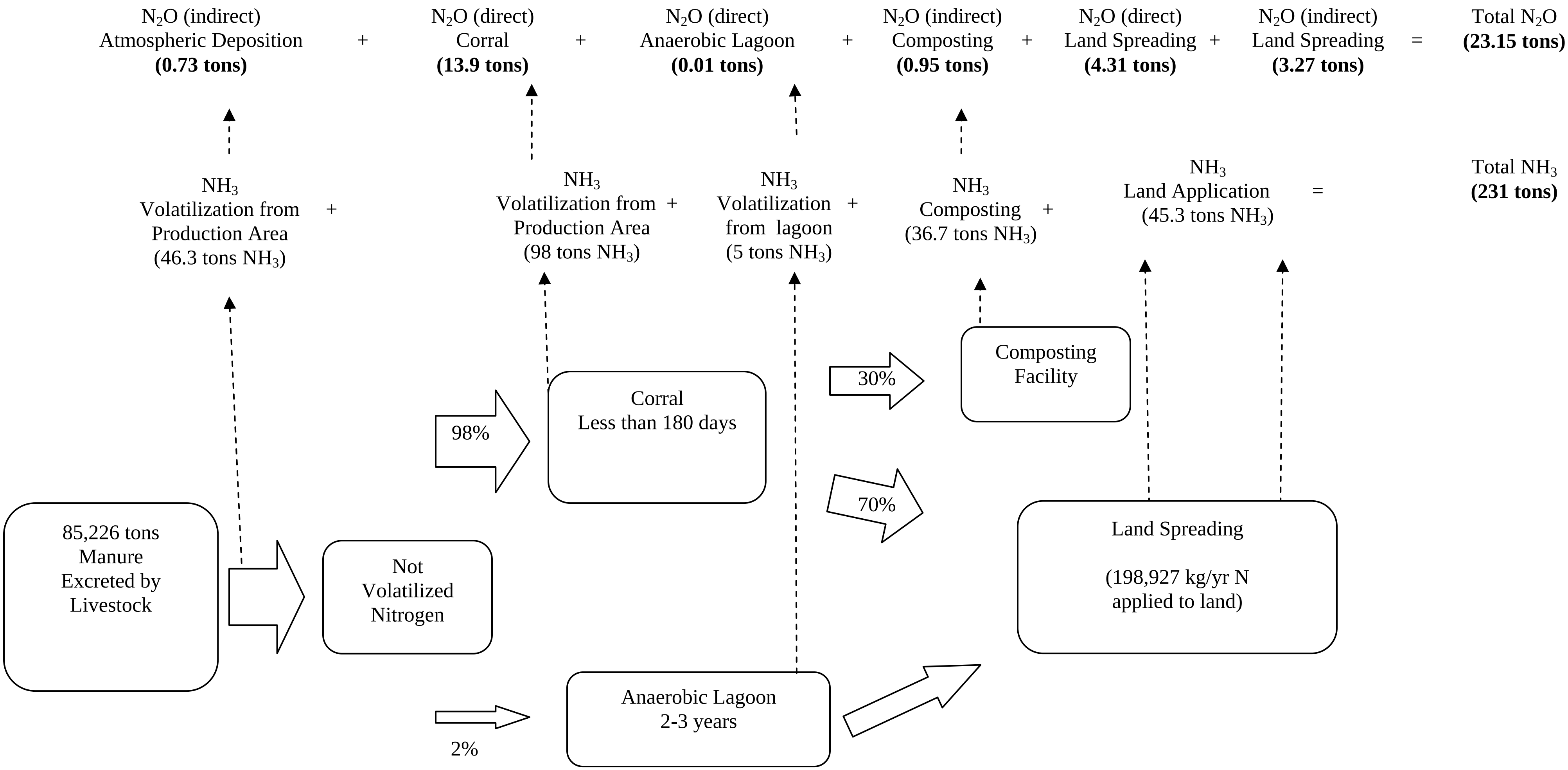


Figure 8. 2003 Nitrogen Compound (NH_3, N_2O) Emissions in IEUA Basecase: Southern California Dairies – No Manure to Digestion



Note:
Direct = Nitrous oxide directly emitted in the atmosphere
Indirect = NH_3 and NO_x enter in the atmosphere and consequentially return to soil through atmospheric deposition enhancing N_2O production

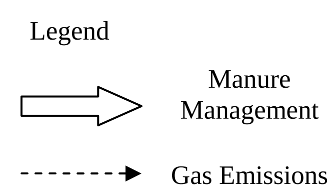
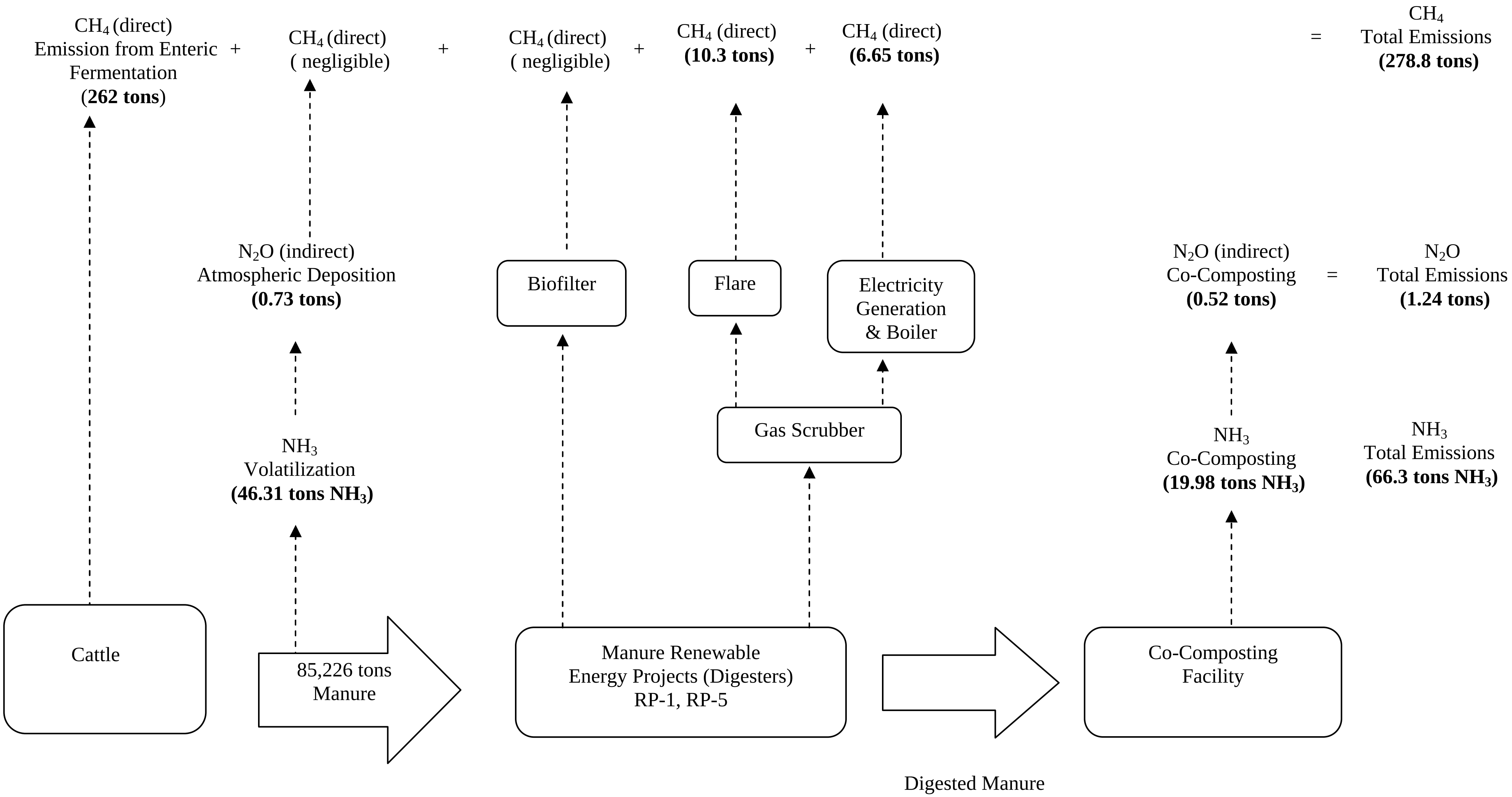
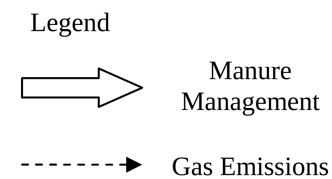


Figure 9. 2003 Greenhouse Gas (CH_4, N_2O) Emissions from IEUA Digester Projects



Note:
Direct = Nitrous oxide or ammonia directly emitted in the atmosphere
Indirect = NH_3 and NO_x enter in the atmosphere and consequentially return to soil through atmospheric deposition enhancing N_2O production



C. Baseline methodology

The methodology contained in the IEUA Digester Model is a robust greenhouse gas and criteria pollutant emissions model developed by Environmental Resources Trust (ERT) and Eastern Research Group (ERG). The baseline emission calculations rely on real measured data to drive a "model farm" approach. The IEUA Digester Model calculates emissions of methane, nitrous oxide and ammonia from lagoon manure management systems and land application systems used at the local dairies that transfer manure to IEUA digesters. This modeling approach has also been used to calculate emissions resulting from project operation, including transportation emissions and stationary combustion emissions, allowing ERT to calculate the amount of emission reductions achieved through operation of the anaerobic digesters at IEUA facilities.

The methodology is currently contained in an MS Excel Workbook and is in a format suitable for integration into IEUA's data management system. ERT recommends this as a means to avoid duplicative data input which is a common source of unintentional errors. The ERT/ERG methodology builds on earlier work by numerous groups including the Intergovernmental Panel on Climate Change, the US Environmental Protection Agency, and the US Department of Agriculture. The IEUA Digester Model was populated with actual measured data provided by IEUA staff. IEUA implemented this Monitoring, Reporting and Verification (MRV) Protocol for 2003 and is investigating the possibility of automating the model for use in 2004 and beyond. As digester operations expand, the methodology will accommodate new digesters. The methodology is set up to incorporate continuing operations into the future as well.

The IEUA Digester Model is used to calculate base case emissions and "with-project" emissions and contains the following discrete steps in individual worksheets:

1. Specification of methane related assumptions and inputs
2. Calculation of methane emissions
3. Specification of nitrogen assumptions and inputs
4. Calculation of nitrous oxide (N_2O) emissions
5. Specification of ammonia assumptions and inputs
6. Calculation of ammonia (NH_3) emissions
7. Mass balance analysis for nitrogen
8. Combustion emissions from the electric generators and flare from RP-1 and RP-5
9. Emissions from transport of manure
10. surface water discharges from the dairies

The objective of the baseline analysis is to estimate emissions of methane (CH_4), nitrous oxide (N_2O), and ammonia (NH_3) associated with manure management at dairies. Emissions both before and after implementation of the IEUA Manure Renewable Energy Projects are estimated.

Methane and ammonia emissions from the following operations are included in the analysis: dairy cattle enteric fermentation (methane only), manure management in the corral and anaerobic lagoon, composting, and land spreading. Nitrous oxide emission estimates include: (1) direct emissions from manure management at the dairy and manure nitrogen applied to soil and (2) indirect emissions from volatilization and subsequent deposition of nitrogen and leaching and runoff of applied nitrogen. Indirect emissions of N_2O associated with leaching at the dairy are not included in the estimates.

Estimates of methane and nitrous oxide emissions are based on the methodology used by US EPA to generate the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks. Methane conversion factors calculated by US EPA for dairy systems in California are used in the methane calculations. Estimates of ammonia emissions are based on currently unpublished draft methodologies developed by US EPA to generate the 2001 National Emission Inventory for animal husbandry operations. The estimates for ammonia have been compared to ammonia inventories recently developed for SCAQMD and are in close agreement.

To generate emission calculations, the daily records of actual manure delivered and processed each day at the RP-1 and RP-5 digesters were used, as were measured values of volatile solids in the manure. Estimates of emissions associated with this manure are based on a site visits to actual southern California dairies. Prior to implementation of the digester, approximately 98 percent of the manure was collected, transported, and spread on fields. The remaining 2 percent of the manure collected was managed in an anaerobic lagoon. The manure solids from the corral were then either applied to land or composted. The liquid manure from the lagoon was applied to land. Following implementation of the digester, the manure from the corral is collected within 24 hours and transported to the digester. The digested solids are either land applied or composted.

The reductions in ammonia and greenhouse gas emissions are obtained by subtracting the base case emissions from the total emissions generated at the IEUA Digester Projects. Site-specific data and literature data were used to select emission factors and to estimate emissions. Combustion byproducts from process water heaters, flare operations, and electricity generation include carbon dioxide emissions, criteria pollutants and small amounts of unburned hydrocarbons. Some methane slippage and leakage is quantified during normal digester operations. See the Appendices for additional details on the baseline and “with project” methodology.

This baseline analysis was refined as a result of peer review and site visits to the actual dairies participating in the project. In January of 2004, a weeklong inspection tour was conducted and site visits to the dairies were employed to establish the validity of all input assumptions. Data examined during the visits included:

- List and info on all participating dairies, including name and size (acres)
- Summary of waste handling systems (by dairy)
- Animal populations (by dairy) (by year)
- Waste handling on each dairy
- Changes in manure management system operation over time
- Characterization of how often solids from lagoon are removed for land application
- Method of manure collection (dry collection, wet flush) by area

D. Initiation of project activity

Construction activity on the digester projects began in year 2000. Digester RP-1 began operation in 2001 and 2001 is the starting date of the project, for the purposes of calculating the project's GHG offset crediting period. During 2001 and 2002 the digester was not yet operating under normal conditions and there are significant gaps in records and data. For this reason, no estimates of emissions and reductions are prepared for 2001 and 2002 even though it is expected that the project achieved additional reductions in these years. Digester RP-5 began operation in 2003.

Expected operational lifetime of this project: 30 years.

E. Monitoring methodology and plan

The monitoring plan addresses how the data inputs required by the baseline model will be monitored. IEUA staff actively monitor all aspects of digester operations and summarize pertinent data in weekly and monthly operating reports for each plant. Daily measurements of manure loading, biogas generation and gas characterization and taken and recorded. IEUA will maintain records of all process operations for at least 5 years. Using this methodology, emission trajectories can be developed with a daily, weekly, or monthly resolution and are capable of capturing seasonal variations in manure loading and methane generation.

The model contains details of all required data inputs and the monitoring plan for this project is based on the current practice of

- daily monitoring of all wastes received at the digester facilities
- regular random samples for manure characteristics such as moisture content, volatile solids, and nitrogen content
- periodic monitoring of dairy conditions and management practices
- continuous metering of biogas flow to flares, engines and boilers
- regular random analysis of biogas composition

Digester RP-5 is equipped with a tipping scale enabling accurate weight measurements of all manure loads delivered to the RP-5 digester. Although RP-1 does not have a scale at this time, IEUA and their contractors have used the scales at RP-5 to develop density profiles for all participating dairies. This allows accurate estimation of weight based on volume even at RP-1.

Figure 10 shows a 25 ton truck being weighed at the RP-5 site.

The plant personnel maintain daily logs of waste loads received and monthly summary totals of all emissions and reductions will be developed following the methodology detailed in this protocol. The data will be archived for at least 5 years in order to facilitate verification.

Data to be collected in order to monitor emissions from the project activity, and how this data will be archived

IEUA staff members and contractors collect daily measurements and record process data covering a wide range of inputs and variables. Data input requirements are summarized in the model. Flow meters are used to measure gas flows to engines and boilers. Flare operation records are used to calculate flows to flares. These results are currently tabulated to obtain monthly apportionment for biogas flows to all combustion devices.

The following table summarizes data input requirements for RP-1:

RP-1 Data Entry Worksheet

Date	Estimated tons received at AMD	% Total Solids	% Volatile Solids	Manure processed at AMD (Kgal/day)	Biogas Production at Digester #4 (1000 ft#/day)

The following table summarizes data input requirements for RP-5:

RP-5 Data Entry Worksheet

Date	Manure Processed	% Total Solids	% Volatile Solids	Biogas Production (scfd)	Biogas Production at Digester #4 (1000 ft#/day)	% CH4 content	Hours of Flare Operation	LPG consumption (gallons)

Potential sources of emissions which may be significant and reasonably attributable to the project activity, but which are not included in the project boundary, and identification if and how data will be collected and archived on these emission sources.

Fugitive emissions of methane from loading operations are not included as these are emissions expected to be negligible. The loading area is kept under negative pressure and all gases from the digester building are vented to a biofilter. No data are available for biofilter methane destruction efficiency; this is an area for ongoing research.

The digesters at IEUA accept food wastes (cheese whey and salad oil byproducts), which are used as an input to feed the digesters. Emission reductions associated with the acceptance of food wastes are not included in this protocol. This is an area of ongoing research.

Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored.

IEUA has an extensive Quality Assurance and Quality Control process in place. All data used for this model is taken directly from IEUA's processing monitoring systems.

F. Third party verification plan

The role of a third party reviewer is in part determined by the reporting program or registry for which the information is intended. Entities seeking to utilize market mechanisms must meet the highest standards for verification. For the purpose of selling emission reductions in the voluntary market, third party verification activities must be sufficient to determine that emission reductions are real, surplus, and quantified within acceptable accuracy levels.

ERT has conducted three site trips to the digester project to gather data on emission sources and processes, to verify the operating conditions of the project. Site visits to inspect the conditions at local dairies was conducted in first and second quarter of 2004. Interviews with the Milk producers Council and local dairymen were conducted to determine how local dairies typically operate and to assess conditions before and after the project began operations. In addition, numerous interviews with plant personnel have been conducted to determine the status of equipment and the quality of data handling procedures. Based on two inspections of the facility, review of the data, and interviews with IIEUA personnel, ERT has verified the environmental performance of the digester for the years 2003 and 2004. The emission reductions achieved by IEUA have been registered in IEUA's account in ERT's GHG Registry (www.ecoregistry.org) in accordance with the terms of ERT's Registry Users Agreement.

ERT will annually verify data submittals from IEUA and will apply audit-sampling methods, and register the verified emissions/reductions for the preceding year's vintage. Annual verification statements will be issued as data is reviewed and verified. ERT will return for follow up site visits at least once ever five years, with prior notification of the facility operators.

Attestation statement

The attestation statement in Appendix C has been signed by management of IEUA and is submitted annually to ERT, along with the project report, following each year of the project's lifetime, or upon submittal of periodic emission reduction documentation for verification and registration.

G. Additionality and Leakage

The primary test as to whether the IEUA Digester Projects lead to additional (i.e., surplus) emission reductions relates to the existing federal, state, or local regulatory requirements on the local dairies to capture and/or treat emissions or to control the manure in more advanced systems than currently employed. To date, the local dairies (and IEUA) have not been required, pursuant to any environmental law, to destroy or control the emissions of methane, ammonia, nitrous oxide or other air pollutants. At such time that the local dairies in Chino are required under any environmental law or any state government law, regulation or rule to change their manure management systems, restrict their land application of manure, or mitigate air emissions, IEUA will advise ERT and the baseline analysis will be reviewed and modified as needed.

ERT does not require or enforce any financial additionality tests, meaning that there is no screen on this project based on expected financial returns, provision of Federal funds to develop the project, etc.

Leakage is the displacement of emissions from inside the project accounting boundary to outside the project boundary, caused by the project activity. All manure handled in the baseline case is handled by the digester and there is no reason to think that the project action has cuased leakage.

H. Stakeholders comments

The baseline analysis and MRV protocol have been widely distributed and are being reviewed under a process organized by the PIER program. The feedback and comments received to date have been evaluated and addressed. Copies of received comments and a brief description of the proposed process for outreach and stakeholder dialogues will be made available to interested parties.

I. Appendices

APPENDIX A – RESULTS FROM THE IEUA DIGESTER MODEL
APPENDIX B – 2004 VERIFICATION STATEMENT FROM ERT
APPENDIX C – ATTESTATION STATEMENT
APPENDIX D – DOCUMENTATION FOR EMISSION FACTORS USED
APPENDIX E – RENEWABLE ENERGY GENERATION DATA

APPENDIX A
RESULTS FROM THE
IEUA DIGESTER MODEL

Summary of Baseline and Post-Digester Emissions for 2004

Summary of Net Baseline and Post-Digester Emissions and Reductions for 2004

Pollutant	GHG Emissions (CH4+N20+CO2)		Ammonia		CO		NOx		SOx	
Baseline Emissions	9,978	tons CO_2-eq /yr	154.9	tons NH3/yr	0.3	tons/yr	0.9	tons/yr	0.0	ton/yr
Post-Digester Emissions	4,153	tons CO_2-eq /yr	44.4	tons NH3/yr	7.5	tons/yr	2.8	tons/yr	0.6	ton/yr
Reductions	5,825	tons CO_2-eq /yr	110.5	tons NH3/yr	-7.2	tons/yr	-1.9	tons/yr	-0.6	ton/yr

Note: GHGs in metric tons; other pollutants in short tons

Note: negative numbers for reductions indicate emissions increases

Emissions Related to Dairy Manure Management (including Composting and Land Application)						
Pollutant	**Methane**		**Nitrous Oxide**		**Ammonia**	
Baseline Emissions	225.0	tons CH4 /yr	16.9	tons N2O/yr	154.9	tons NH3/yr
Post-Digester Emissions	175.5	tons CH4 /yr	0.5	tons N2O/yr	44.4	tons NH3/yr
Reductions	49.6	tons CH4 /yr	16.4	tons N2O/yr	110.5	tons NH3/yr

Emissions Related to the Transportation of Manure										
Pollutant	**VOC**		**CO**		**NOx**		**CO2**		**Methane**	
Baseline Emissions	143.2	lbs CH4/yr/truck	538	tons/yr	1,819	tons/yr	184,013	tons/yr	6.7	tons/yr
Post-Digester Emissions	94.9	lbs CH4/yr/truck	432.3	tons/yr	1,366	tons/yr	134,277	tons/yr	4.4	tons/yr
Reductions	48.3	lbs CH4/yr/truck	106	tons/yr	452	tons/yr	49,736	tons/yr	2.25	tons/yr

Emissions Related to Combustion of Biogas at RP-1 and RP-5										
Pollutant	**CO2**		**CO**		**NOx**		**SOx**		**Methane**	
Baseline Emissions	0.0	tons/yr	0.0	tons/yr	0.0	tons/yr	0.0	tons/yr	0.0	tons/yr
Post-Digester Emissions	67.9	tons/yr	7.3	tons/yr	2.1	tons/yr	0.5	tons/yr	11.7	tons/yr
Reductions	-67.9	tons/yr	-7.3	tons/yr	-2.1	tons/yr	-0.5	tons/yr	-11.7	tons/yr

Note: negative numbers for reductions indicate emissions increases

Summary of Baseline and Post-Digester Emissions for 2003

Summary of Net Baseline and Post-Digester Emissions and Reductions for 2003

Pollutant	GHG Emissions (CH4+N20+CO2)		Ammonia		CO		NOx		SOx	
Baseline Emissions	14,249	tons CO_2-eq /yr	231.2	tons NH3/yr	0.4	tons/yr	1.4	tons/yr	0.0	ton/yr
Post-Digester Emissions	6,242	tons CO_2-eq /yr	66.3	tons NH3/yr	10.0	tons/yr	3.6	tons/yr	0.7	ton/yr
Reductions	8,008	tons CO_2-eq /yr	164.9	tons NH3/yr	-9.6	tons/yr	-2.2	tons/yr	-0.7	ton/yr

Note: GHGs in metric tons; other pollutants in short tons

Note: negative numbers for reductions indicate emissions increases

Emissions Related to Dairy Manure Management (including Composting and Land Application)						
Pollutant	**Methane**		**Nitrous Oxide**		**Ammonia**	
Baseline Emissions	336.8	tons CH4 /yr	23.1	tons N2O/yr	231.2	tons NH3/yr
Post-Digester Emissions	261.9	tons CH4 /yr	1.2	tons N2O/yr	66.3	tons NH3/yr
Reductions	74.9	tons CH4 /yr	21.9	tons N2O/yr	164.9	tons NH3/yr

Emissions Related to the Transportation of Manure										
Pollutant	**VOC**		**CO**		**NOx**		**CO2**		**Methane**	
Baseline Emissions	213.7	lbs VOC/yr	803	lbs CO/yr	2,715	lbs NOx/yr	274,683	lbs CO2/yr	10.0	lbs CH4/yr
Post-Digester Emissions	94.9	lbs VOC/yr	432.3	lbs CO/yr	1,366	lbs NOx/yr	134,277	lbs CO2/yr	4.4	lbs CH4/yr
Reductions	118.8	lbs VOC/yr	371	lbs CO/yr	1,348	lbs NOx/yr	140,405	lbs CO2/yr	5.55	lbs CH4/yr

Emissions Related to Combustion of Biogas at RP-1 and RP-5										
Pollutant	**TOC**		**CO**		**NOx**		**SOx**		**Methane**	
Baseline Emissions	0.0	tons/yr	0.0	tons/yr	0.0	tons/yr	0.0	tons/yr	0.0	tons/yr
Post-Digester Emissions	58.4	tons/yr	9.8	tons/yr	2.9	tons/yr	0.7	tons/yr	16.9	tons/yr
Reductions	-58.4	tons/yr	-9.8	tons/yr	-2.9	tons/yr	-0.7	tons/yr	-16.9	tons/yr

Assumptions and Calculations for Quantifying Greenhouse Gas Emissions from the IEUA Digester Gas Renewable Energy Projects

Table 1. Digester Gas Analysis (RP-1)*

Component	Formula	Mole %	Mol Wt.	Weight %
Nitrogen	N_2	3.95	28	4.10
Carbon Dioxide	CO_2	37.00	44	60.29
Methane	CH_4	58.00	16	34.37
Oxygen	O_2	1.05	32	1.24
Total %		100.00		100.00
MW_{MIX}			27.00	
Wt. %C_{MIX}				
HHV (Btu/scf)	629.36			

* based on annual averages from IEUA and Synagro testing

Table 2. Digester Gas Analysis (RP-5)*

Component	Formula	Mole %	Mol Wt.	Weight %
Nitrogen	N_2	3.16	28	3.29
Carbon Dioxide	CO_2	37.00	44	60.58
Methane	CH_4	59.00	16	35.13
Oxygen	O_2	0.84	32	1.00
Total %		100.00		100.00
MW_{MIX}			26.87	
Wt. %C_{MIX}				
HHV (Btu/scf)	640.21			

* based on annual averages from IEUA and Synagro testing
* see RP-5 Biogas Analysis.xls

Table 3. Emission Factors Developed From On-site Test Data (RP-1)

	NOx	CO	PM 10	SOx
Flare (lb/10^6 scf biogas)	36.00	20.00	5.00	16.00
Engine (lb/10^6 scf biogas)	44.58	425.93	7.50	10.42
Boiler (lb/10^6 scf biogas)	24.61	1.75	5.00	16.00

* Emission factors represent high end of actual permitted values
* Based on actual tests or BACT limits accepted by SCAQMD (see AER 2003)

Table 4. Emission Factors Developed From On-site Test Data (RP-5)

	NOx	CO	CO2	PM 10	CH4	SOx
Flare (lb/10^6 scf biogas)	36.00	20.00	-	5.00		16.00
Engine (lb/10^6 scf biogas)	96.00	10.20	-	7.20		3.90
Boiler (lb/10^6 scf biogas)	24.61	1.75	-	5.00		16.00
Water Heater (lb/1000 gal propane)	12.80	3.20	12,500	0.28	0.28	4.60

* Emission factors represent high end of actual permitted values
* Based on actual tests or BACT limits accepted by SCAQMD (see AER 2003)

Table 5. Default combustion device methane destruction efficiency

Flare =	98.0%
IC engine =	99.9%
Boiler =	98.0%

Based on standard US EPA guidance and GEP.

Table 6. Natural Gas Analysis (typical)

Component	Formula	Mole %	Mol Wt.	Carbon Content (%)	Weight %
Nitrogen	N_2	0.17	28	0	0.27
Carbon Dioxide	CO_2	3.78	44	27.3	9.46
Methane	CH_4	94.00	16	75	85.51
Ethane	C_2H_6	1.00	30	80	1.71
Propane	C_3H_8	0.70	44	81.8	1.75
Iso-butane	C_4H_{10}	0.08	58	82.8	0.26
n-butane	C_4H_{10}	0.12	58	82.8	0.40
Iso-pentane	C_5H_{12}	0.04	72	83.3	0.16
n-pentane	C_5H_{12}	0.03	72	83.3	0.12
C6+	C_6H_{XX}	0.08	80	90	0.36
Total %		100			100
MW_{MIX}			17.59		
Wt. $\%C_{MIX}$				70.62	
HHV (Btu/scf)	1020				

BACKGROUND DATA (not used in calculations)

Table 7. Engine Emission Factors (from AP-42, Table 3.2-2, uncontrolled EFs for 4 stroke lean-burn engines)

	NOx	CO	TOC	Methane	PM2.5	SO_2
(lbs/MMBtu)	4.08	0.32	1.47	1.25	0.00008	
(lbs/MMscf Natgas)	4,162	323	1,499	1,275	0	
(lbs/MMscf biogas)	2,568	200	925	787	0	

IEUA Engines: Waukesha VHP 7100GLD; 1000 kW and 850 kW electrical generators
Source for other emission factors:

Table 8. Boiler Emission Factors (from AP-42, Tables 1.4-1, and 1.4-2; small boiler, low NOx Burners, flue gas recirculation)

	NOx	CO	TOC	Methane	PM2.5	SO_2
(lbs/MMscf NatGas)	32.0	84.0	11.0	2.3	7.6	
(lbs/MMscf biogas)	32.0	84.0	11.0	2.3	7.6	

IEUA Boilers RP-1: Burnham, Firetube, Low NOx Burners, power flame, induced flue gas recirculation
Source for other emission factors:

Table 9. Flare Emission Factors (from AP-42, Tables 13.5-1, and 13.5-2)

	NOx	CO	TOC	Methane	PM2.5	SO_2
(lbs/MMBtu)	0.068	0.37	0.14	0.077		
(lbs/MMscf NatGas)	69.4	377.4	142.8	78.5	-	
(lbs/MMscf biogas)	42.8	232.9	88.1	48.5	-	

Flare emission hydrocarbon composition assumed 55% methane as per AP-42 table 13.5-2
Source for other emission factors:

Table 10. Landfill Gas Emission Factors (from AP-42, Table 2.4-4)

	NO2	CO	PM
Flare ($lb/10^6$ dscfm methane)	40	750	17
Engine ($lb/10^6$ dscfm methane)	250	470	48
Boiler ($lb/10^6$ dscfm methane)	33	5.7	8.2

1 g-mol = 24.47 liters (@ 25 C, 1 atm)

Assumptions and Calculations for Estimated Annual Methane (CH_4) Emission Reductions from the Dairies of the IEUA Manure Renewable Energy Projects

ASSUMPTIONS:

		Unit of Measurement	2003	2004
1	Average manure daily processed at the RP-1 Manure Digester (RP-1 Data)	tons/day	93	82
2	Average manure daily processed at the RP-5 Manure Digester (RP-5 Data)	tons/day	141	75
3	Average manure Total Solid (TS) concentration at RP-1 (RP-1 Data)	%	15.0%	14.7%
	Average manure Total Solid (TS) concentration at RP-5 (RP-5 Data)	%	15.0%	14.7%
4	Average manure Volatile Solid (VS) concentration at RP-1 (RP-1 Data)	%	72.5%	72.3%
	Average manure Volatile Solid (VS) concentration at RP-5 (RP-5 Data)	%	72.5%	72.3%
5	Daily cattle manure production (Milk Producers Council, 2003)	lbs/day	120	120
6	Methane emission factor for dairy cattle (EIIP Vol VIII, Chapt 6 Methods for Estimating Methane Emissions from Domesticated Animals, Oct. 99 Table 6.4-2)	lbs CH4/head/yr	134.6	134.6
7	Maximum methane producing capacity for dairy cattle (Bo) (EIIP Vol VIII, Chapt 7 Methods for Estimating Greenhouse Gas Emissions from Manure Management, Oct. 99 Table 7.4-13)	ft3/lbs-VS	3.84	3.84
8	Methane Conversion Factor for anaerobic lagoon (MCF) (Developed for San Bernadino CA climate using the methodology from US EPA, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2002 - Draft* , Oct. 03) * See calculation below		0.789	0.793
9	Methane Conversion Factor for corral and other manure management systems (MCF) (Temperate climate MCF from IPCC, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* , June 2001 Table 4.10		0.015	0.015
10	Percentage of manure lost from corral/feed lanes as runoff (managed in an anaerobic lagoon) [See worksheet entitled Runoff Estimate]	%	2%	2%
11	Percentage of manure deposited that stays in corral	%	98%	98%
12	Methane density (US EPA, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2002 - Draft* , Oct. 03)	lbs/ft3	0.04221	0.04221
13	Manure from corral shipped to co-composting facility (Milk Producers Council, 2003)	%	30%	30%
14	Manure from corral used as bulking agent or land spread (Milk Producers Council, 2003)	%	70%	70%
15	Methane emission factor for co-composting facil (SCAQMD Source Test Report 95-0032/96-0003 Conducted at EKO Systems 8100-100 Chino-Corona Road Corona, CA 91720)		2.23	2.23

CH4 CALCULATIONS: 2003

A Calculate methane emissions from enteric fermentation of dairy cattle

Calculate average manure daily processed at RP-1 and RP-5

92.71282192	tons/day	+	140.784	tons/day	=	233.496411	tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2000	lbs/tons	=	0.06	tons/day

Calculate cattle population served by RP-1 and RP-5

233.496411	tons/day	/	0.06	tons/day	=	3891.606849	head

Calculate methane emissions for dairy cattle

3891.606849	head	*	134.6	lbs CH_4/head/yr	=	523810.2819	lbs CH_4/yr

Convert methane emissions for dairy cattle to tons/yr

523810.2819	lbs CH_4/yr	/	2000	lbs/tons	=	**261.905141**	tons CH_4/yr

Enteric Emissions

B Calculate methane emissions from corrals

Calculate amount of total solids of manure that is daily processed at RP-1 and RP-5

92.71282192	tons/day	*	0.14997		=	13.90401688	tons/day	RP-1 TS
				140.783589	=	21.113125	tons/day	RP-5 TS

Calculate amount of volatile solids of manure that is daily processed at RP-1 and RP-5

13.90401688	tons/day	*	0.7246		=	10.07	tons/day	RP-1 VS
				21.113125	=	15.29853576	tons/day	RP-5 VS

Calculate amount of volatile solids of manure that is annual processed at RP-1 and RP-5

25.37	tons/day	*	365	day/yr	=	9261.28	tons/yr	VS

Convert volatile solids to lbs/yr

9261.277712	tons/yr	*	2000	lbs/tons	=	18522555.42	lbs/yr	VS

Calculate maximum methane producing capacity from manure

18522555.42	lbs/yr	*	3.84	ft^3/lbs-VS	=	71126612.83	ft^3 CH_4 /yr

Calculate the volume of methane emissions from corrals. Note that 98% of manure is left in corrals and that the Methane Conversion Factor for drylots is 1.5%

71126612.83	ft^3 CH_4 /yr	*	0.97892	*	0.015	=	1044408.725	ft^3 CH_4 /yr

Calculate the mass of methane emissions from corrals.

1044408.725	ft^3 CH_4 /yr	*	0.04221	lbs/ft^3	=	44079.47505	lbs CH_4 /yr

Convert methane emissions from corrals to tons/yr

44079.47505	lbs CH_4 /yr	/	2000	lbs/tons	=	**22.03973753**	tons CH_4 /yr

Drylot Emissions

C Calculate methane emissions from anaerobic lagoons

Calculate the volume of methane emissions from anaerobic lagoons. Note that 2% of manure is managed with anaerobic lagoon and that the Methane Conversion Factor for anaerobic lagoons in CA is 78%

71126612.83 ft^3 CH_4 /yr * 0.02108 * 0.78904161 = 1183060.944 ft^3 CH_4 /yr

Calculate the mass of methane emissions from corrals.

1183060.944 ft^3 CH_4 /yr * 0.04221 lbs/ft^3 = 49931.31914 lbs CH_4 /yr

Convert methane emissions from corrals to tons/yr

49931.31914 lbs CH_4 /yr / 2000 lbs/tons = **24.96565957** tons CH_4 /yr

Lagoon Emissions

D Calculate methane emissions from co-composting facility

Calculate manure annual processed at RP-1 and RP-5

233.496411 tons/day * 365 day/yr = 85226.19 tons/yr

Calculate manure left in the corrals

85226.19 tons/yr * 0.97892 = 83429.60338 tons/yr

Calculate manure shipped from corrals to the co-composting facility

83429.60338 tons/yr * 0.3 = 25028.88102 tons/yr

Calculate methane emissions from the co-composting facility

25028.88102 tons/yr * 2.23 = 55814.40466 lbs CH_4 /yr

Convert methane emissions from co-composting to tons/yr

55814.40466 lbs CH_4 /yr / 2000 lbs/tons = **27.90720233** tons CH_4 /yr

Co-Composting Emissions

TOTAL BASELINE CH4 EMISSIONS

E Calculate total baseline methane emissions

= **336.8177404** tons CH_4 /yr

CH4 CALCULATIONS: 2004

A Calculate methane emissions from enteric fermentation of dairy cattle

Calculate average manure daily processed at RP-1 and RP-5

82	tons/day	+	75	tons/day	=	156	tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2,000	lbs/tons	=	0.06	tons/day

Calculate cattle population served by RP-1 and RP-5

156	tons/day	/	0.06	tons/day	=	2,607	head

Calculate methane emissions for dairy cattle

2,607	head	*	134.6	lbs CH_4/head/yr	=	350,907	lbs CH_4/yr

Convert methane emissions for dairy cattle to tons/yr

350,907	lbs CH_4/yr	/	2,000	lbs/tons	=	**175**	tons CH_4/yr
						Enteric	Emissions

B Calculate methane emissions from corrals

Calculate amount of total solids of manure that is daily processed at RP-1

82	tons/day	*	14.7%		=	11.98	tons/day	RP-1 TS
75	tons/day	*	14.7%		=	11.00	tons/day	RP-5 TS

Calculate amount of volatile solids of manure that is daily processed at RP-

11.98	tons/day	*	72.3%		=	8.67	tons/day	RP-1 VS
11.00	tons/day	*	72.3%		=	7.95	tons/day	RP-5 VS

Calculate amount of volatile solids of manure that is annual processed at

16.62	tons/day	*	365	day/yr	=	6,065.76	tons/yr	VS

Convert volatile solids to lbs/yr

6,065.76	tons/yr	*	2,000	lbs/tons	=	12,131,527	lbs/yr	VS

Calculate maximum methane producing capacity from manure

12,131,527	lbs/yr	*	3.84	ft^3/lbs-VS	=	46,585,064	ft^3 CH_4 /yr

Calculate the volume of methane emissions from corrals. Note that 98% of

46,585,064	ft^3 CH_4 /yr	*	98%	*	1.5%	=	684,046	ft^3 CH_4 /yr

Calculate the mass of methane emissions from corrals.

684,046	ft^3 CH_4 /yr	*	0.04221	lbs/ft^3	=	28,870	lbs CH_4 /yr

Convert methane emissions from corrals to tons/yr

28,870	lbs CH_4 /yr	/	2,000	lbs/tons	=	**14**	tons CH_4 /yr
						Drylot	Emissions

C Calculate methane emissions from anaerobic lagoons

Calculate the volume of methane emissions from anaerobic lagoons. Note

46,585,064	ft^3 CH_4 /yr	*	2%	*	79%	=	779,144	ft^3 CH_4 /yr

Calculate the mass of methane emissions from corrals.

779,144	ft^3 CH_4 /yr	*	0.04221	lbs/ft^3	=	32,884	lbs CH_4 /yr

Convert methane emissions from corrals to tons/yr

32,884	lbs CH_4 /yr	/	2,000	lbs/tons	=	**16**	tons CH_4 /yr

Lagoon Emissions

D Calculate methane emissions from co-composting facility

Calculate manure annual processed at RP-1 and RP-5

156.4222137	tons/day	*	365	day/yr	=	57,094	tons/yr

Calculate manure left in the corrals

57,094	tons/yr	*	98%	=	55,891	tons/yr

Calculate manure shipped from corrals to the co-composting facility

55,891	tons/yr	*	30%	=	16,767	tons/yr

Calculate methane emissions from the co-composting facility

16,767	tons/yr	*	2.23	=	37,391	lbs CH_4 /yr

Convert methane emissions from co-composting to tons/yr

37,391	lbs CH_4 /yr	/	2,000	lbs/tons	=	19	tons CH_4 /yr

Co-Composting Emissions

TOTAL BASELINE CH4 EMISSIONS

E Calculate total baseline methane emissions

= $\boxed{\textbf{225}\text{ tons } CH_4 \text{ /yr}}$

Assumptions and Calculations for Estimated Annual Nitrous Oxide Emission Reductions from the Dairies of the IEUA Manure Renewable Energy Projects

ASSUMPTIONS:

	Item	Unit of Measurement	2003	2004
Nitrogen Excreted				
1	Average manure daily processed at the RP-1 Manure Digester (RP-1 Data)	tons/day	92.71	82
2	Average manure daily processed at the RP-5 Manure Digester (RP-5 Data)	tons/day	140.78	75
3	Typical dairy cattle mass (TAM) (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Table 9.4-1)	kg	640	640
4	Kjeldahl nitrogen excreted (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Table 9.4-1)	kg/day/1000 kg mass	0.45	0.45
5	Daily cattle manure production (Milk Producers Council, 2003)	lbs/day	120	120
Production Area				
6	Percentage of manure lost from corral/feed lanes as runoff (managed in an anaerobic lagoon) [See worksheet entitled Runoff Estimate]	%	2%	2%
7	Percentage of manure deposited that stays in corral	%	98%	98%
8	Nitrous oxide (N_2O) emission factor for anaerobic lagoon (EIIP Vol VIII, Chapt 7 Methods for Estimating Greenhouse Gas Emissions from Manure Management, Oct. 99 Page 7.4-19)	kg N2O-N/Kg N excreted	0.001	0.001
9	Nitrous oxide (N_2O) emission factor for corral and other manure management systems (EIIP Vol VIII, Chapt 7 Methods for Estimating Greenhouse Gas Emissions from Manure Management, Oct. 99 Table 7.4-20)	N2O-N/Kg N excreted	0.02	0.02
Indirect Prodn Area N2O Emissions				
10	Percentage of total nitrogen **excreted at the drylot** that volatilizes to ammonia (NH_3) (US EPA, *National Emission Inventory—Ammonia Emissions from Animal Husbandry Operations - Draft* , April 2005 Page 3-14)	lbs NH3/head/yr	23.8	23.8
11	Nitrous oxide (N_2O) emission factor resulting from ammonia (NH_3) and oxides of nitrogen (NO_x) volatilization (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Table 9.4-7)	N/kg NH3-N + NOx -N	0.01	0.01
12	Conversion factor for nitrous oxide (N_2O) to nitrogen gas (N_2)		44/28	44/28

Direct Land Application N2O Emissions				
13	Manure from corral used as bulking agent or land spread (Milk Producers Council, 2003)	%	70%	70%
14	Nitrous oxide (N_2O) emission factor for land spreading (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Table 9.4-3)	kg N2O-N/Kg N applied	0.0125	0.0125
Indirect Land Application N2O Emissions				
15	Percentage of total nitrogen **applied to land** that volatilizes to ammonia (NH_3) and oxides of nitrogen (NO_x) (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Page 9.4-4)	%	20%	20%
16	Percentage of total nitrogen that leaches or runs off (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Page 9.4-16)	%	30%	30%
17	Nitrous oxide (N_2O) emission factor for leaching and runoff (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Page 9.4-16)	kg N2O-N/Kg N applied	0.025	0.025
Co-Composting N2O Emissions				
18	Manure from corral shipped to co-composting facility (Milk Producers Council, 2003)	%	30%	30%
19	Ammonia (NH_3) emission factor for co-composting facility (SCAQMD PR 1133)	lbs/ton	2.93	2.93
20	Conversion factor for ammonia (NH_3) to nitrogen gas (N_2)		28/17	28/17
21	Manure mass reduction due to dewatering process following digestion (RP-5 Data, November 2002 - January 2003)	%	60%	60%
22	Nitrogen removal efficiency due to anaerobic digestion (RP-1 Data, 2002)	%	60%	60%

N2O CALCULATIONS: 2003

CALCULATE NITROGEN EXCRETED

A Calculate nitrogen excreted from dairy cattle

Calculate maximum manure daily processed at RP-1 and RP-5

93	tons/day	+	141	tons/day	=	233 tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2,000	lbs/tons	=	0.06 tons/day

Calculate cattle population served by RP-1 and RP-5

233	tons/day	/	0.06	tons/day	=	3,892 head

Calculate Kjeldahl Nitrogen Excreted per day for each dairy cattle

640	kg	*	0.45	(kg/day/1000 kg mass)	=	0.29 kg/day

Calculate Kjeldahl Nitrogen Excreted per year for each dairy cattle

0.29	kg/day	*	365	days/yr	=	105.12 kg/yr

Calculate Total Kjeldahl Nitrogen Excreted per year

105.12	kg/yr	*	3,892	head	=	409,086 kg/yr

CALCULATE DIRECT N2O EMISSIONS FROM PRODUCTION AREA

B Calculate nitrous oxide emissions from corrals

Calculate nitrogen content in the manure left in the corral or managed through other

409,086	kg/yr	*	98%		=	400,462 kg/yr

Calculate nitrous oxide emissions from corrals

400,462	kg/yr	*	0.02	kg N_2O-N/Kg N	=	8,009 kg N_2O-N/yr

Convert nitrogen emissions from corral from N_2 to N_2O

8,009	kg N_2O-N/yr	*	44/28		=	12,586 kg N_2O/yr

Convert kilograms to tons

12,586	kg N_2O/yr	/	907	kg/tons	=	**13.87 tons N_2O/yr corrals**

C Calculate nitrous oxide emissions from the anaerobic lagoon

Calculate nitrogen content in the manure managed through anarobic lagoon

409,086	kg/yr	*	2%		=	8,624 kg/yr

Calculate nitrous oxide emissions from anaerobic lagoon

8,624	kg/yr	*	0.001	kg N_2O-N/Kg N	=	9 kg N_2O-N/yr

Convert nitrogen emissions from anaerobic lagoon from N_2 to N_2O

9	kg N_2O-N/yr	*	44/28		=	14 kg N_2O/yr

Convert kilograms to tons

14	kg N_2O/yr	/	907	kg/tons	=	**0.01 tons N_2O/yr lagoon**

CALCULATE INDIRECT N2O EMISSIONS FROM PRODUCTION AREA

D Calculate nitrous oxide emissions from dairy cattle drylots

Calculate nitrogen that volatilizes to NH_3 and NO_x

3,892	head	*	11	kg NH3/head/yr	=	42,012	kg/yr

Calculate nitrogen that volatilizes to N_2O

42,012	kg/yr	*	0.01	(kg N2O-N/kg NH3-N + NOx -N)	=	420	kg N_2O-N/yr

Convert nitrogen that volatilizes from N_2 to N_2O

420	kg N20-N/yr	*	44/28		=	660	kg N_2O/yr

Convert kilograms to tons

660	kg N20/yr	/	907	kg/tons	=	**0.73**	**tons N_2O/yr**

production area volatilization

CALCULATE NITROGEN APPLIED TO LAND

E Calculate nitrogen applied to land

Calculate nitrogen remaining in corrals after air losses

400,462	kg/yr	-	8,009	kg N2O-N/yr	=	284,253	kg/yr
		-	9	kg N2O-N/yr			
		-	420	kg N2O-N/yr			
		-	38	tons NH3-N/yr			
		-	81	tons NH3-N/yr			

Calculate nitrogen content in the manure used as bulking agent

284,253	kg/yr	*	70%		=	198,977	kg/yr

CALCULATE DIRECT N2O LAND APPLICATION EMISSIONS

F Calculate nitrous oxide emissions from land spreading

Calculate nitrous oxide emissions from land spreading activities

198,977	kg/yr	*	0.0125	kg N_2O-N/Kg N	=	2,487	kg N_2O-N/yr

Convert nitrogen emissions from land spreading from N_2 to N_2O

2,487	kg N_2O-N/yr	*	44/28		=	3,908	kg N_2O/yr

Convert kilograms to tons

3,908	kg N_2O/yr	/	907	kg/tons	=	**4.31**	**tons N_2O/yr**

land application

CALCULATE INDIRECT N2O LAND APPLICATION EMISSIONS

G Calculate nitrous oxide indirect emissions from leaching and runoff

Calculate nitrogen that leaches or runs off from land application field

198,977	kg/yr	*	30%		=	59,693	kg/yr

Calculate nitrous oxide that leach or run off

59,693	kg/yr	*	0.025	(kg N2O-N/Kg N applied)	=	1,492	kg N_2O-N

Convert nitrogen that leach or run off from N_2 to N_2O

1,492	kg N2O-N	*	44/28		=	2,345	kg N_2O/yr

Convert kilograms to tons

2,345	kg N2O/yr	/	907	kg/tons	=	**2.59**	**tons N_2O/yr land leach/runoff**

H Calculate nitrous oxide emissions from volatilization

Calculate nitrogen that volatilizes to NH_3 and NO_x

198,977	kg/yr	*	20%		=	39,795	kg/yr

Calculate nitrogen that volatilizes to N_2O

39,795	kg/yr	*	0.01	(kg N2O-N/kg NH3-N + NOx -N)	=	398	kg N_2O-N/yr

Convert nitrogen that volatilizes from N_2 to N_2O

398	kg N2O-N/yr	*	44/28		=	625	kg N_2O/yr

Convert kilograms to tons

625	kg N2O/yr	/	907	kg/tons	=	**0.69**	**tons N_2O/yr land volatilization**

CALCULATE N2O EMISSIONS FROM CO-COMPOSTING

I Calculate nitrous oxide emissions from co-composting facility

Calculate manure annual processed at RP-1 and RP-5

233	tons/day	*	365	day/yr	=	85,226	tons/yr

Calculate manure left in the corrals

85,226	tons/yr	*	98%		=	83,430	tons/yr

Calculate manure shipped from corrals to the co-composting facility

83,430	tons/yr	*	30%		=	25,029	tons/yr

Calculate ammonia emissions from the co-composting facility

25,029	tons/yr	*	2.93	(lbs/ton)	=	73,335	lbs NH_3/yr

Convert ammonia emissions from co-composting to tons/yr

73,335	lbs NH_3/yr	/	2,000	lbs/tons	=	36.67	tons NH_3/yr

Convert nitrogen emissions from corral from NH_3 to N_2

36.67	tons NH_3/yr	*	28/17		=	60.39	tons N_2/yr

Calculate nitrous oxide emissions from co-composting facilities

60.39	tons N_2/yr	*	0.01	tons N_2O-N/tons NH_3-N	=	0.60	tons N_2O-N/yr

Convert nitrogen emissions from co-composting facilities from N_2 to N_2O

0.60	tons N_2O-N/yr	*	44/28		=	**0.95**	**tons N_2O/yr co-composting**

TOTAL BASELINE N2O EMISSIONS

J Calculate total baseline nitrous oxide emissions

				=	$\boxed{\textbf{23.15}}$	**tons N_2O/yr**

K Calculate total nitrous oxide emissions associated with an anaerobic manure digester and co-composting facility

Calculate manure shipped from the anaerobic digestor to the co-composting facillity

85,226	tons/yr	*	40%		=	34,090	tons/yr

Calculate ammonia emission factor for digested manure managed at a co-composting facillity

2.93	lbs/ton	*	40%		=	1.172	lbs/ton

Calculate ammonia emissions from the co-composting facility

34,090	tons/yr	*	1.172	lbs/ton	=	39,954	lbs NH_3/yr

Convert ammonia emissions from co-composting to tons/yr

39,954	lbs NH_3/yr	/	2,000	lbs/tons	=	19.98	tons NH_3/yr

Convert nitrogen emissions from corral from NH_3 to N_2

19.98	tons NH_3/yr	*	28/17		=	32.90	tons N_2/yr

Calculate nitrous oxide emissions from co-composting facilities

32.90	tons N_2/yr	*	0.01	tons N_2O-N/tons NH_3-N	=	0.33	tons N_2O-N/yr

Convert nitrogen emissions from co-composting facilities from N_2 to N_2O

0.33	tons N_2O-N/yr	*	44/28		=	**0.52**	**tons N_2O/yr**

L Calculate total nitrous oxide emissions associated with an anaerobic manure digester and co-composting facility

0.73	**tons N_2O/yr**	**+**	**0.52**	**tons N_2O/yr**	**=**	$\boxed{\textbf{1.24}}$	**tons N_2O/yr**

M Calculate nitrous oxide emission reduction due to anaerobic manure digester and co-composting facility

23.15	**tons N_2O/yr**	**-**	**1.24**	**tons N_2O/yr**	**=**	$\boxed{\textbf{21.90}}$	**tons N_2O/yr**

N2O CALCULATIONS: 2004

CALCULATE NITROGEN EXCRETED

A Calculate nitrogen excreted from dairy cattle

Calculate maximum manure daily processed at RP-1 and RP-5

82	tons/day	+	75	tons/day	=	156	tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2,000	lbs/tons	=	0.06	tons/day

Calculate cattle population served by RP-1 and RP-5

156	tons/day	/	0.06	tons/day	=	2,607	head

Calculate Kjeldahl Nitrogen Excreted per day for each dairy cattle

640	kg	*	0.45	(kg/day/1000 kg mass)	=	0.29	kg/day

Calculate Kjeldahl Nitrogen Excreted per year for each dairy cattle

0.29	kg/day	*	365	days/yr	=	105.12	kg/yr

Calculate Total Kjeldahl Nitrogen Excreted per year

105.12	kg/yr	*	2,607	head	=	274,052	kg/yr

CALCULATE DIRECT N2O EMISSIONS FROM PRODUCTION AREA

B Calculate nitrous oxide emissions from corrals

Calculate nitrogen content in the manure left in the corral or managed through other

274,052	kg/yr	*	98%		=	268,275	kg/yr

Calculate nitrous oxide emissions from corrals

268,275	kg/yr	*	0.02	kg N_2O-N/Kg N	=	5,365	kg N_2O-N/yr

Convert nitrogen emissions from corral from N_2 to N_2O

5,365	kg N_2O-N/yr	*	44/28		=	8,431	kg N_2O/yr

Convert kilograms to tons

8,431	kg N_2O/yr	/	907	kg/tons	=	**9.29**	**tons N_2O/yr corrals**

C Calculate nitrous oxide emissions from the anaerobic lagoon

Calculate nitrogen content in the manure managed through anarobic lagoon

274,052	kg/yr	*	2%		=	5,777	kg/yr

Calculate nitrous oxide emissions from anaerobic lagoon

5,777	kg/yr	*	0.001	kg N_2O-N/Kg N	=	6	kg N_2O-N/yr

Convert nitrogen emissions from anaerobic lagoon from N_2 to N_2O

6	kg N_2O-N/yr	*	44/28		=	9	kg N_2O/yr

Convert kilograms to tons

9	kg N_2O/yr	/	907	kg/tons	=	**0.01**	**tons N_2O/yr lagoon**

CALCULATE INDIRECT N2O EMISSIONS FROM PRODUCTION AREA

D Calculate nitrous oxide emissions from dairy cattle drylots

Calculate nitrogen that volatilizes to NH_3 and NO_x

2,607	head	*	11	kg NH3/head/yr	=	28,144	kg/yr

Calculate nitrogen that volatilizes to N_2O

28,144	kg/yr	*	0.01	(kg N2O-N/kg NH3-N + NOx -N)	=	281	kg N_2O-N/yr

Convert nitrogen that volatilizes from N_2 to N_2O

281	kg N20-N/yr	*	44/28		=	442	kg N_2O/yr

Convert kilograms to tons

442	kg N20/yr	/	907	kg/tons	=	**0.49**	**tons N_2O/yr production area volatilization**

CALCULATE NITROGEN APPLIED TO LAND

E Calculate nitrogen applied to land

Calculate nitrogen remaining in corrals after air losses

268,275	kg/yr	-	5,365	kg N2O-N/yr	=	244,270	kg/yr
		-	6	kg N2O-N/yr			
		-	281	kg N2O-N/yr			
		-	-	tons NH3-N/yr			
		-	20	tons NH3-N/yr			

Calculate nitrogen content in the manure used as bulking agent

244,270	kg/yr	*	70%		=	170,989	kg/yr

CALCULATE DIRECT N2O LAND APPLICATION EMISSIONS

F Calculate nitrous oxide emissions from land spreading

Calculate nitrous oxide emissions from land spreading activities

170,989	kg/yr	*	0.0125	kg N_2O-N/Kg N	=	2,137	kg N_2O-N/yr

Convert nitrogen emissions from land spreading from N_2 to N_2O

2,137	kg N_2O-N/yr	*	44/28		=	3,359	kg N_2O/yr

Convert kilograms to tons

3,359	kg N_2O/yr	/	907	kg/tons	=	**3.70**	**tons N_2O/yr land application**

CALCULATE INDIRECT N2O LAND APPLICATION EMISSIONS

G Calculate nitrous oxide indirect emissions from leaching and runoff

Calculate nitrogen that leaches or runs off from land application field

170,989	kg/yr	*	30%		=	51,297	kg/yr

Calculate nitrous oxide that leach or run off

51,297	kg/yr	*	0.025	(kg N2O-N/Kg N applied)	=	1,282	kg N_2O-N

Convert nitrogen that leach or run off from N_2 to N_2O

1,282	kg N2O-N	*	44/28		=	2,015	kg N_2O/yr

Convert kilograms to tons

2,015	kg N2O/yr	/	907	kg/tons	=	**2.22**	**tons N_2O/yr land leach/runoff**

H Calculate nitrous oxide emissions from volatilization

Calculate nitrogen that volatilizes to NH_3 and NO_x

170,989	kg/yr	*	20%		=	34,198	kg/yr

Calculate nitrogen that volatilizes to N_2O

34,198	kg/yr	*	0.01	(kg N2O-N/kg NH3-N + NOx -N)	=	342	kg N_2O-N/yr

Convert nitrogen that volatilizes from N_2 to N_2O

342	kg N2O-N/yr	*	44/28		=	537	kg N_2O/yr

Convert kilograms to tons

537	kg N2O/yr	/	907	kg/tons	=	**0.59**	**tons N_2O/yr land volatilization**

CALCULATE N2O EMISSIONS FROM CO-COMPOSTING

I Calculate nitrous oxide emissions from co-composting facility

Calculate manure annual processed at RP-1 and RP-5

156	tons/day	*	365	day/yr	=	57,094	tons/yr

Calculate manure left in the corrals

57,094	tons/yr	*	98%		=	55,891	tons/yr

Calculate manure shipped from corrals to the co-composting facility

55,891	tons/yr	*	30%		=	16,767	tons/yr

Calculate ammonia emissions from the co-composting facility

16,767	tons/yr	*	2.93	(lbs/ton)	=	49,128	lbs NH_3/yr

Convert ammonia emissions from co-composting to tons/yr

49,128	lbs NH_3/yr	/	2,000	lbs/tons	=	24.56	tons NH_3/yr

Convert nitrogen emissions from corral from NH_3 to N_2

24.56	tons NH_3/yr	*	28/17		=	40.46	tons N_2/yr

Calculate nitrous oxide emissions from co-composting facilities

40.46	tons N_2/yr	*	0.01	tons N_2O-N/tons NH_3-N	=	0.40	tons N_2O-N/yr

Convert nitrogen emissions from co-composting facilities from N_2 to N_2O

0.40	tons N_2O-N/yr	*	44/28		=	**0.64**	**tons N_2O/yr co-composting**

TOTAL BASELINE N2O EMISSIONS

J Calculate total baseline nitrous oxide emissions

					=	**16.94**	**tons N_2O/yr**

K Calculate total nitrous oxide emissions associated with an anaerobic manure

Calculate manure shipped from the anaerobic digestor to the co-composting facillity

57,094	tons/yr	*	40%		=	228	tons/yr

Calculate ammonia emission factor for digested manure managed at a

2.93	lbs/ton	*	40%		=	2.930	lbs/ton

Calculate ammonia emissions from the co-composting facility

228	tons/yr	*	2.930	lbs/ton	=	669	lbs NH_3/yr

Convert ammonia emissions from co-composting to tons/yr

669	lbs NH_3/yr	/	2,000	lbs/tons	=	0.33	tons NH_3/yr

Convert nitrogen emissions from corral from NH_3 to N_2

0.33	tons NH_3/yr	*	28/17		=	0.55	tons N_2/yr

Calculate nitrous oxide emissions from co-composting facilities

0.55	tons N_2/yr	*	0.01	tons N_2O-N/tons NH_3-N	=	0.01	tons N_2O-N/yr

Convert nitrogen emissions from co-composting facilities from N_2 to N_2O

0.01	tons N_2O-N/yr	*	44/28		=	**0.01**	**tons N_2O/yr**

L Calculate total nitrous oxide emissions associated with an anaerobic manure

0.49	**tons N_2O/yr**	**+**	**0.01**	**tons N_2O/yr**	**=**	**0.50**	**tons N_2O/yr**

M Calculate nitrous oxide emission reduction due to anaerobic manure digester and

16.94	**tons N_2O/yr**	**-**	**0.50**	**tons N_2O/yr**	**=**	**16.45**	**tons N_2O/yr**

Assumptions and Calculations for
Estimated Annual Ammonia Emission Reductions from
the Dairies of the IEUA Manure Renewable Energy Projects

ASSUMPTIONS:

		Unit of Measurement	2003	2004
Nitrogen Excreted				
1	Average manure daily processed at the RP-1 Manure Digester (RP-1 Data)	tons/day	93	82
2	Average manure daily processed at the RP-5 Manure Digester (RP-5 Data)	tons/day	141	75
3	Typical dairy cattle mass (TAM) (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Table 9.4-1)	kg	640	640
4	Kjeldahl nitrogen excreted per day per 1000 kg mass (EIIP Vol VIII, Chapt 9 Methods for Estimating Greenhouse Gas Emissions from Agricultural Soils, October 1999 Table 9.4-1)	kg/day/1000 kg mass	0.45	0.45
5	Daily cattle manure production (Milk Producers Council, 2003)	lbs/day	120	120
Production Area				
6	Percentage of manure lost from corral/feed lanes as runoff (managed in an anaerobic lagoon) [See worksheet entitled Runoff Estimate]	%	2%	2%
7	Percentage of manure deposited that stays in corral	%	98%	98%
8	Ammonia (NH3) emission factor for **anaerobic lagoon** (US EPA, *National Emission Inventory—Ammonia Emissions from Animal Husbandry Operations - Draft* , April 2005 Page 3-14)	%	43%	43%
10	Percentage of total nitrogen **excreted at the drylot** that volatilizes to ammonia (NH_3) (US EPA, *National Emission Inventory—Ammonia Emissions from Animal Husbandry Operations - Draft* , April 2005 Page 3-14)	lbs NH3/head/yr	23.8	23.8
11	Percentage of total nitrogen **stockpiled** that volatilizes to ammonia (NH_3) (US EPA, *National Emission Inventory—Ammonia Emissions from Animal Husbandry Operations - Draft* , April 2005 Page 3-14)	%	20%	20%
11	Conversion factor for ammonia-N (NH3-N) to ammonia (NH3)		17/14	17/14

Land Application				
12	Manure from corral used as bulking agent or land spread (Milk Producers Council, 2003)	%	70%	70%
13	Ammonia (NH3) emission factor for land spreading (US EPA, National Emission Inventory—Ammonia Emissions from Animal Husbandry Operations - Draft, April 2005 Page 3-14)	%	17%	17%
Co-Composting				
14	Manure from corral shipped to co-composting facility (Milk Producers Council, 2003)	%	30%	30%
15	Ammonia (NH3) emission factor for co-composting facility (SCAQMD PR 1133)	lbs/ton	2.93	2.93
16	Conversion factor for ammonia (NH_3) to nitrogen gas (N_2)		28/17	28/17
17	Manure mass reduction due to dewatering process following digestion (RP-5 Data, November 2002 - January 2003)	%	60%	60%
18	Nitrogen removal efficiency due to anaerobic digestion (RP-1 Data, 2002)	%	60%	60%

NH3 CALCULATIONS: 2003

CALCULATE NITROGEN EXCRETED

A Calculate nitrogen excreted from dairy cattle

Calculate maximum manure daily processed at RP-1 and RP-5

93	tons/day	+	141	tons/day	=	233 tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2,000	lbs/tons	=	0.06 tons/day

Calculate cattle population served by RP-1 and RP-5

233	tons/day	/	0.06	tons/day	=	3,892 head

Calculate Kjeldahl Nitrogen Excreted per day for each dairy cattle

640	kg	*	0.45	(kg/day/1000 kg mass)	=	0.29 kg/day

Calculate Kjeldahl Nitrogen Excreted per year for each dairy cattle

0.29	kg/day	*	365	days/yr	=	105.12 kg/yr

Calculate Total Kjeldahl Nitrogen Excreted per year

105.12	kg/yr	*	3,892	head	=	409,086 kg/yr

CALCULATE DIRECT NH3 EMISSIONS FROM PRODUCTION AREA

B Calculate ammonia emissions from corrals

Calculate nitrogen content in the manure left in the corral or managed through other systems

409,086	kg/yr	*	98%		=	400,462 kg/yr

Calculate ammonia emissions from corrals

3,892	head	*	23.80	(lbs NH3/head/yr)	=	92,620 lbs NH3/yr

Convert pounds to tons

92,620	lbs NH3/yr	/	2,000	lb/ton	=	**46.31 tons NH3/yr corrals**

C Calculate ammonia emissions from stockpiles

Calculate nitrogen content in the stockpiled manure

400,462	kg/yr	-	92,620	lbs NH3/yr	=	365,864 kg/yr

Calculate ammonia emissions from stockpiles

365,864	kg/yr	*	20%		=	73,173 kg NH3-N/yr

Convert nitrogen emissions from stockpile from NH3-N to NH3

73,173	kg NH3-N/yr	*	17/14		=	88,853 kg NH3/yr

Convert kilograms to tons

88,853	kg NH3/yr	/	907	kg/ton	=	**97.94 tons NH3/yr stockpiles**

D Calculate ammonia emissions from the anaerobic lagoon

Calculate nitrogen content in the manure managed through anarobic lagoon

409,086	kg/yr	*	2%		=	8,624	kg/yr

Calculate nitrogen emissions from anaerobic lagoon

8,624	kg/yr	*	43%		=	3,708	kg NH3-N/yr

Convert nitrogen emissions from anaerobic lagoon from NH3-N to NH3

3,708	kg NH3-N/yr	*	17/14		=	4,503	kg NH3/yr

Convert kilograms to tons

4,503	kg NH3/yr	/	907	kg/tons	=	**4.96**	**tons NH3/yr lagoon**

CALCULATE NITROGEN APPLIED TO LAND

E Calculate nitrogen applied to land

Calculate nitrogen remaining in corrals after air losses

400,462	kg/yr	-	8,009	kg N2O-N/yr	=	284,253	kg/yr
		-	9	kg N2O-N/yr			
		-	420	kg N2O-N/yr			
		-	38	tons NH3-N/yr			
		-	81	tons NH3-N/yr			

Calculate nitrogen content in the manure used as bulking agent

284,253	kg/yr	*	70%		=	198,977	kg/yr

CALCULATE DIRECT NH3 EMISSIONS FROM LAND APPLICATION AREA

F Calculate ammonia emissions from land spreading

Calculate nitrogen emissions volatilized

198,977	kg/yr	*	17%		=	33,826	kg NH3-N/yr

Convert nitrogen emissions from land spreading from NH3-N to NH3

33,826	kg NH3-N/yr	*	17/14		=	41,075	kg NH3/yr

Convert kilograms to tons

41,075	kg NH3/yr	/	907	kg/tons	=	**45.28**	**tons NH3/yr land application**

CALCULATE N2O EMISSIONS FROM CO-COMPOSTING

G Calculate nitrous oxide emissions from co-composting facility

Calculate manure annual processed at RP-1 and RP-5

233 tons/day	*	365 day/yr	=	85,226	tons/yr	

Calculate manure left in the corrals

85,226 tons/yr	*	98%	=	83,430	tons/yr

Calculate manure shipped from corrals to the co-composting facility

83,430 tons/yr	*	30%	=	25,029	tons/yr

Calculate ammonia emissions from the co-composting facility

25,029 tons/yr	*	2.93 lbs/ton	=	73,335	lbs NH_3/yr

Convert ammonia emissions from co-composting to tons/yr

73,335 lbs NH3/yr	/	2,000 lbs/ton	=	**36.67**	**tons NH_3/yr co-composting**

TOTAL BASELINE NH3 EMISSIONS

H Calculate total baseline ammonia emissions

= **231.16 tons NH3/yr**

I Calculate total ammonia emissions associated with an anaerobic manure digester and co-composting facility

Calculate manure shipped from the anaerobic digestor to the co-composting facillity

85,226 tons/yr	*	40%	=	34,090	tons/yr

Calculate ammonia emission factor for digested manure managed at a co-composting facillity

2.93 lbs/ton	*	40%	=	1.17

Calculate ammonia emissions from the co-composting facility

34,090 tons/yr	*	1.17	=	**39,954**	**lbs NH_3/yr**

J Calculate total ammonia emissions associated with an anaerobic manure digester and co-composting facility

46.31 tons NH3/yr	**+**	**19.98 tons NH3/yr**	=	**66.29**	**tons NH3/yr**

K Calculate ammonia emission reduction due to anaerobic manure digester and co-composting facility

231.16 tons NH3/yr	**-**	**66.29 tons NH3/yr**	=	**164.87**	**tons NH3/yr**

CALCULATE NITROGEN EXCRETED: 2003

A Calculate nitrogen excreted from dairy cattle

Calculate maximum manure daily processed at RP-1 and RP-5

93	tons/day	+	141	tons/day	=	233	tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2000	lbs/tons	=	0.06	tons/day

Calculate cattle population served by RP-1 and RP-5

233.4964	tons/day	/	0.06	tons/day	=	3892	head

Calculate Kjeldahl Nitrogen Excreted per day for each dairy cattle

640	kg	*	0.45	kg/day/1000 kg mass	=	0.288	kg/day

Calculate Kjeldahl Nitrogen Excreted per year for each dairy cattle

0.288	kg/day	*	365	days/yr	=	105.12	kg/yr

Calculate Total Kjeldahl Nitrogen Excreted per year

105.12	kg/yr	*	3,892	head	=	**409,086**	**kg/yr**
					=	**901,879**	**lb/yr**
					=	**451**	**tons/yr**

B Calculate losses of nitrogen throughout production area

46.31	tons NH3/yr	corrals	=	38.1	tons N
97.94	tons NH3/yr	stockpiles	=	80.7	tons N
4.96	tons NH3/yr	lagoon	=	4.1	tons N
9.29	tons N2O/yr	corrals	=	5.9	tons N
0.01	tons N2O/yr	lagoon	=	0.0	tons N
0.73	tons N2O/yr	production area	=	0.5	tons N

C Calculate losses of nitrogen throughout land application area

45.28	tons NH3/yr	land application	=	37.3	tons N
4.31	tons N2O/yr	land application	=	2.7	tons N
2.59	tons N2O/yr	land leach/runoff	=	1.6	tons N
0.69	tons N2O/yr	land volatilization	=	0.4	tons N

D Calculate losses of nitrogen from co-composting

36.67	tons NH3/yr	co-composting	=	30.2	tons N
0.95	tons N2O/yr	co-composting	=	0.6	tons N
				202.2	**tons N**
				45%	**loss of N**

NH3 CALCULATIONS: 2004

CALCULATE NITROGEN EXCRETED

A Calculate nitrogen excreted from dairy cattle

Calculate maximum manure daily processed at RP-1 and RP-5

82	tons/day	+	75	tons/day	=	156	tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2,000	lbs/tons	=	0.06	tons/day

Calculate cattle population served by RP-1 and RP-5

156	tons/day	/	0.06	tons/day	=	2,607	head

Calculate Kjeldahl Nitrogen Excreted per day for each dairy cattle

640	kg	*	0.45	(kg/day/1000 kg mass)	=	0.29	kg/day

Calculate Kjeldahl Nitrogen Excreted per year for each dairy cattle

0.29	kg/day	*	365	days/yr	=	105.12	kg/yr

Calculate Total Kjeldahl Nitrogen Excreted per year

105.12	kg/yr	*	2,607	head	=	274,052	kg/yr

CALCULATE DIRECT NH3 EMISSIONS FROM PRODUCTION AREA

B Calculate ammonia emissions from corrals

Calculate nitrogen content in the manure left in the corral or managed

274,052	kg/yr	*	98%		=	268,275	kg/yr

Calculate ammonia emissions from corrals

2,607	head	*	23.80	(lbs NH3/head/yr)	=	62,047	lbs NH3/yr

Convert pounds to tons

62,047	lbs NH3/yr	/	2,000	lb/ton	=	**31.02**	**tons NH3/yr corrals**

C Calculate ammonia emissions from stockpiles

Calculate nitrogen content in the stockpiled manure

268,275	kg/yr	-	62,047	lbs NH3/yr	=	245,097	kg/yr

Calculate ammonia emissions from stockpiles

245,097	kg/yr	*	20%		=	49,019	kg NH3-N/yr

Convert nitrogen emissions from stockpile from NH3-N to NH3

49,019	kg NH3-N/yr	*	17/14		=	59,524	kg NH3/yr

Convert kilograms to tons

59,524	kg NH3/yr	/	907	kg/ton	=	**65.61**	**tons NH3/yr stockpiles**

D Calculate ammonia emissions from the anaerobic lagoon

Calculate nitrogen content in the manure managed through anarobic

274,052	kg/yr	*	2%		=	5,777	kg/yr

Calculate nitrogen emissions from anaerobic lagoon

5,777	kg/yr	*	43%		=	2,484	kg NH3-N/yr

Convert nitrogen emissions from anaerobic lagoon from NH3-N to NH3

2,484	kg NH3-N/yr	*	17/14		=	3,016	kg NH3/yr

Convert kilograms to tons

3,016	kg NH3/yr	/	907	kg/tons	=	**3.33**	**tons NH3/yr lagoon**

CALCULATE NITROGEN APPLIED TO LAND

E Calculate nitrogen applied to land

Calculate nitrogen remaining in corrals after air losses

268,275	kg/yr	-	5,365	kg N2O-N/yr	=	190,425	kg/yr
		-	6	kg N2O-N/yr			
		-	281	kg N2O-N/yr			
		-	26	tons NH3-N/yr			
		-	54	tons NH3-N/yr			

Calculate nitrogen content in the manure used as bulking agent

190,425	kg/yr	*	70%		=	133,297	kg/yr

CALCULATE DIRECT NH3 EMISSIONS FROM LAND APPLICATION AREA

F Calculate ammonia emissions from land spreading

Calculate nitrogen emissions volatilized

133,297	kg/yr	*	17%		=	22,661	kg NH3-N/yr

Convert nitrogen emissions from land spreading from NH3-N to NH3

22,661	kg NH3-N/yr	*	17/14		=	27,516	kg NH3/yr

Convert kilograms to tons

27,516	kg NH3/yr	/	907	kg/tons	=	**30.33**	**tons NH3/yr land application**

CALCULATE N2O EMISSIONS FROM CO-COMPOSTING

G Calculate nitrous oxide emissions from co-composting facility

Calculate manure annual processed at RP-1 and RP-5

156 tons/day	*	365 day/yr	=	57,094	tons/yr	

Calculate manure left in the corrals

57,094 tons/yr	*	98%	=	55,891	tons/yr

Calculate manure shipped from corrals to the co-composting facility

55,891 tons/yr	*	30%	=	16,767	tons/yr

Calculate ammonia emissions from the co-composting facility

16,767 tons/yr	*	2.93 lbs/ton	=	49,128	lbs NH_3/yr

Convert ammonia emissions from co-composting to tons/yr

49,128 lbs NH3/yr	/	2,000 lbs/ton	=	**24.56**	**tons NH_3/yr co-composting**

TOTAL BASELINE NH3 EMISSIONS

H Calculate total baseline ammonia emissions

= 154.86 tons NH3/yr

I Calculate total ammonia emissions associated with an anaerobic

Calculate manure shipped from the anaerobic digestor to the co-

57,094 tons/yr	*	40%	=	22,838	tons/yr

Calculate ammonia emission factor for digested manure managed at a

2.93 lbs/ton	*	40%	=	1.17

Calculate ammonia emissions from the co-composting facility

22,838 tons/yr	*	1.17	=	**26,766**	**lbs NH_3/yr**

J Calculate total ammonia emissions associated with an anaerobic

31.02 tons NH3/yr	**+**	**13.38 tons NH3/yr**	**=**	**44.41**	**tons NH3/yr**

K Calculate ammonia emission reduction due to anaerobic manure

154.86 tons NH3/yr	**-**	**44.41 tons NH3/yr**	**=**	**110.45**	**tons NH3/yr**

CALCULATE NITROGEN EXCRETED: 2004

A Calculate nitrogen excreted from dairy cattle

Calculate maximum manure daily processed at RP-1 and RP-5

82	tons/day	+	75	tons/day	=	156	tons/day

Convert daily cattle manure production to tons/day

120	lbs/day	/	2000	lbs/tons	=	0.06	tons/day

Calculate cattle population served by RP-1 and RP-5

156.4222	tons/day	/	0.06	tons/day	=	2607	head

Calculate Kjeldahl Nitrogen Excreted per day for each dairy cattle

640	kg	*	0.45	kg/day/1000 kg mass	=	0.288	kg/day

Calculate Kjeldahl Nitrogen Excreted per year for each dairy cattle

0.288	kg/day	*	365	days/yr	=	105.12	kg/yr

Calculate Total Kjeldahl Nitrogen Excreted per year

105.12	kg/yr	*	2,607	head	=	**274,052**	**kg/yr**
					=	**604,180**	**lb/yr**
					=	**302**	**tons/yr**

B Calculate losses of nitrogen throughout production area

31.02	tons NH3/yr	corrals	=	25.5	tons N
65.61	tons NH3/yr	stockpiles	=	54.0	tons N
3.33	tons NH3/yr	lagoon	=	2.7	tons N
9.29	tons N2O/yr	corrals	=	5.9	tons N
0.01	tons N2O/yr	lagoon	=	0.0	tons N
0.49	tons N2O/yr	production area	=	0.3	tons N

C Calculate losses of nitrogen throughout land application area

30.33	tons NH3/yr	land application	=	25.0	tons N
3.70	tons N2O/yr	land application	=	2.4	tons N
2.22	tons N2O/yr	land leach/runoff	=	1.4	tons N
0.59	tons N2O/yr	land volatilization	=	0.4	tons N

D Calculate losses of nitrogen from co-composting

24.56	tons NH3/yr	co-composting	=	20.2	tons N
0.64	tons N2O/yr	co-composting	=	0.4	tons N
				138.3	**tons N**
				46%	**loss of N**

Assumptions and Calculations for
Estimated Annual Emissions from Transportaion of Manure
from the Dairies of the IEUA Manure Renewable Energy Projects

ASSUMPTIONS:		**Unit of Measurement**	**2003**		**2004**	
1 Class of truck used to transport manure		truck type	Nurse Tanker	End Dump	Nurse Tanker	End Dump
Gross Vehicle Weight		lbs	45,000	32,000	45,000	32,000
(Milk Producers Council - Nathan de Boom, 2004)						
2 VOC emission factor for trucks		g/mile	1.0095	1.0475	1.0095	1.0475
(MOBILE6.2)						
3 CO emission factor for trucks		g/mile	5.3631	3.9368	5.3631	3.9368
(MOBILE6.2)						
4 NOx emission factor for trucks		g/mile	16.1566	13.3069	16.1566	13.3069
(MOBILE6.2)						
5 CO2 emission factor for trucks		g/mile	1552.7	1346.5	1552.7	1346.5
(MOBILE6.2)						
6 CH4 emission factor for trucks		g/mile	0.0471	0.0489	0.0471	0.0489
(MOBILE6.2)						
7 Miles traveled by truck to transport manure to RP-1 per day		miles/day/truck	60		60	
(Milk Producers Council - Nathan de Boom, 2004)						
8 Miles traveled by truck to transport manure to RP-5 per day		miles/day/truck	55		55	
(Milk Producers Council - Nathan de Boom, 2004)						
9 Times per year manure is transported to digesters	RP-1	trips/yr	365		365	
(Milk Producers Council - Nathan de Boom, 2004)	RP-5	trips/yr	312		312	
10 GVW of truck used to transport manure to RP-1		lbs	45,000		45,000	
(Milk Producers - Nathan de Boom, 2004)						
11 GVW of truck used to transport manure to RP-5		lbs	32,000		32,000	
(Milk Producers - Nathan de Boom, 2004)						
12 Truck model year of engine		yr	1995		1995	
(Milk Producers - Nathan de Boom, 2004)						
13 Truck fuel type		fuel type	Diesel		Diesel	
(Milk Producers Council - Nathan de Boom, 2004)						
14 Miles traveled by truck to tranport manure pre-digesters		miles/trip/truck	85		85	
(Milk Producers Council - Nathan de Boom, 2004)						
15 Amount of manure transported to digesters per day		tons/day	233		156	
(RP-1 and RP-5 digesters' data)						
16 Amount of manure (as excreted) stockpiled to be shipped		tons/yr	59,658		39,966	
17 % Moisture of as excreted dairy manure		%	88%		88%	
(NRCS, Agricultural Waste Management Field Handbook)						
18 % Moisture of dairy manure shipped to Riverside County		%	65%		65%	
(Milk Producers Council - Nathan de Boom, 2004)						
19 Amount of manure transported to digesters per year		tons/year	21,818		14,616	
(Equation from: EPA Cost Methodology for CAFO's)						
20 Truck load capacity		tons/truck	20		20	
(Milk Producers Council - Nathan de Boom, 2004)						
21 Truck loads per year needed to transport manure		trips/year	1,091		731	

Manure Transport Calc: 2003

Calculate methane emissions from transportation of manure pre-digesters

Calculate VOC emissions												
85	miles/trip	*	1.05	gr/mile	=	0.1959	lbs/day	*	1,091	trips/yr	=	214 lbs VOC/yr
Calculate CO emissions												
85	miles/trip	*	3.94	gr/mile	=	0.7362	lbs/day	*	1,091	trips/yr	=	803 lbs CO/yr
Calculate NOx emissions												
85	miles/trip	*	13.31	gr/mile	=	2.4884	lbs/day	*	1,091	trips/yr	=	2,715 lbs NOx/yr
Calculate CO_2 emissions												
85	miles/trip	*	1,347	gr/mile	=	251.80	lbs/day	*	1,091	trips/yr	=	274,683 lbs CO_2/yr
Calculate CH_4 emissions												
85	miles/trip	*	0.05	gr/mile	=	0.0091	lbs/day	*	1,091	trips/yr	=	9.98 lbs CH_4/yr

Calculate methane emissions from transportation of manure to RP-5

Calculate VOC emissions												
55	miles/trip	*	1.05	g/mile	=	0.1267	lbs/day	*	365	trips/yr	=	46 lbs VOC/yr/truck
Calculate CO emissions												
55	miles/trip	*	3.94	g/mile	=	0.4764	lbs/day	*	365	trips/yr	=	174 lbs CO/yr/truck
Calculate NOx emissions												
55	miles/trip	*	13.31	g/mile	=	1.6101	lbs/day	*	365	trips/yr	=	588 lbs NOx/yr/truck
Calculate CO_2 emissions												
55	miles/trip	*	1,347	g/mile	=	162.93	lbs/day	*	365	trips/yr	=	59,468 lbs CO_2/yr/truck
Calculate CH_4 emissions												
55	miles/trip	*	0.049	g/mile	=	0.0059	lbs/day	*	365	trips/yr	=	2.16 lbs CH_4/yr/truck

Calculate methane emissions from transportation of manure to RP-1

Calculate VOC emissions												
60	miles/trip	*	1.01	g/mile	=	0.1333	lb/yr	*	365	trips/yr	=	49 lbs VOC/yr/truck
Calculate CO emissions												
60	miles/trip	*	5.36	g/mile	=	0.7079	lb/yr	*	365	trips/yr	=	258 lbs CO/yr/truck
Calculate NOx emissions												
60	miles/trip	*	16.16	g/mile	=	2.1327	lb/yr	*	365	trips/yr	=	778 lbs NOx/yr/truck
Calculate CO_2 emissions												
60	miles/trip	*	1,553	g/mile	=	204.96	lb/yr	*	365	trips/yr	=	74,809 lbs CO_2/yr/truck
Calculate CH_4 emissions												
60	miles/trip	*	0.047	g/mile	=	0.0062	lb/yr	*	365	trips/yr	=	2.27 lbs CH_4/yr/truck

Calculate emissions from transportation of dewatered manure from RP-5 to Co-composting

Calculate emissions from transportation of dewatered manure from RP-1 to Co-composting

additional milage=	RP-5	3 to 4 loads per day * 3 miles/load (6 days a week)
	RP-1	1 to 2 loads per day * 8 miles/load (7 days per week)

Manure Transport Calc: 2004

Calculate methane emissions from transportation of manure pre-digesters

Calculate VOC emissions

85 miles/trip * 1.05 gr/mile = 0.1959 lbs/day * 731 trips/yr = 143 lbs VOC/yr

Calculate CO emissions

85 miles/trip * 3.94 gr/mile = 0.7362 lbs/day * 731 trips/yr = 538 lbs CO/yr

Calculate NOx emissions

85 miles/trip * 13.31 gr/mile = 2.4884 lbs/day * 731 trips/yr = 1,819 lbs NOx/yr

Calculate CO_2 emissions

85 miles/trip * 1,347 gr/mile = 251.80 lbs/day * 731 trips/yr = 184,013 lbs CO_2/yr

Calculate CH_4 emissions

85 miles/trip * 0.05 gr/mile = 0.0091 lbs/day * 731 trips/yr = 6.68 lbs CH_4/yr

Calculate methane emissions from transportation of manure to RP-5

Calculate VOC emissions

55 miles/trip * 1.05 g/mile = 0.1267 lbs/day * 365 trips/yr = 46 lbs VOC/yr/truck

Calculate CO emissions

55 miles/trip * 3.94 g/mile = 0.4764 lbs/day * 365 trips/yr = 174 lbs CO/yr/truck

Calculate NOx emissions

55 miles/trip * 13.31 g/mile = 1.6101 lbs/day * 365 trips/yr = 588 lbs NOx/yr/truck

Calculate CO_2 emissions

55 miles/trip * 1,347 g/mile = 162.93 lbs/day * 365 trips/yr = 59,468 lbs CO_2/yr/truck

Calculate CH_4 emissions

55 miles/trip * 0.049 g/mile = 0.0059 lbs/day * 365 trips/yr = 2.16 lbs CH_4/yr/truck

Calculate methane emissions from transportation of manure to RP-1

Calculate VOC emissions

60 miles/trip * 1.01 g/mile = 0.1333 lb/yr * 365 trips/yr = 49 lbs VOC/yr/truck

Calculate CO emissions

60 miles/trip * 5.36 g/mile = 0.7079 lb/yr * 365 trips/yr = 258 lbs CO/yr/truck

Calculate NOx emissions

60 miles/trip * 16.16 g/mile = 2.1327 lb/yr * 365 trips/yr = 778 lbs NOx/yr/truck

Calculate CO_2 emissions

60 miles/trip * 1,553 g/mile = 204.96 lb/yr * 365 trips/yr = 74,809 lbs CO_2/yr/truck

Calculate CH_4 emissions

60 miles/trip * 0.047 g/mile = 0.0062 lb/yr * 365 trips/yr = 2.27 lbs CH_4/yr/truck

Calculate emissions from transportation of dewatered manure from RP-5 to Co-composting

Calculate emissions from transportation of dewatered manure from RP-1 to Co-composting

additional milage=	RP-5	3 to 4 loads per day * 3 miles/load (6 days a week)
	RP-1	1 to 2 loads per day * 8 miles/load (7 days per week)

Assumptions and Calculations for Estimated Volatile Solids in Manure Runoff Managed in Lagoons from the Dairies of the IEUA Manure Renewable Energy Projects

ASSUMPTIONS:

1	CN (USDA, NRCS, Technical Release 55, Estimating Runoff)	87	
2	S (USDA, NRCS, Technical Release 55, Estimating Runoff)	1.4943	
3	Number of cows	1	Head
4	Drylot area per cow (Midwest Plan Service)	460	ft^2
5	Avg. cow mass (Milk Producers' Council - Nathan de Boom, 2004)	1450	lbs
6	Weight of dairy manure Table 4-5 Ag Waste Handbook (as excreted)	80	lb/d/1000
7	TS in dairy manure as excreted Table 4-5 Ag Waste Handbook (as excreted)	10	lb/d/1000
8	Percent of TS that are VS Table 4-5 Ag Waste Handbook (as excreted)	85%	
9	Amount of solids in runoff from drylots MWPS, 1993	1.5%	
10	Density of manure	62.4%	
11	Amount of manure deposited in corrals/feed lanes AWMFH	85%	
12	Amount of manure deposited in milking parlor AWMFH	15%	
13	Twenty five year runoff average See rainfall data below	101	ft3/yr

CALCULATIONS:

Runoff solids, ft3/yr	1.52	ft3/yr
Runoff solids, lb/yr	95	lb/yr
Volatile solids in runoff	81	lb/yr
Manure per cow	116	lb/day
TS per cow	15	lb/day
VS per cow per day	12	lb/day
VS per cow per year	4499	lb/yr
VS per cow in drylot	3824	lb/yr
% of manure VS in runoff	2	%

List and info on 10 dairies

	Del Amo Dairy	Dykstra Dairy	GH Dairy	Gold Star Dairy	Gorzeman Dairy #1	Gorzeman Dairy #2	Hillview Dairy	Legend Dairy	Marquez Dairy
1 Name									
size (acres)	60	60	80	40	30	60	30	80	40
2 Animal populations									
milking cows	1200	1100	1600	1100	700	1200	550	1100	750
dry cows	200	170	300	134	300	200	80	200	150
heifers	100	1400			100		150	800	40
calves		200						200	120
3 Waste handling on each dairy									
waste collected and transported to IEUA	waste from feeding lane	waste from feeding lane	waste from feeding lane	waste from feeding lane	waste from feeding lane	waste from feeding lane	waste from feeding lane	waste from feeding lane	waste from feeding lane
changes in manure management system over time	transports manure to composter	transports manure to composter	installed separator	transports manure to composter			dairy hauls own manure to farmland		dairy hauls own manure to farmland
how often manure was collected and stockpiled prior to the digester project going online	twice a year	twice a year	twice a year	twice a year	twice a year	twice a year	continually	twice a year	continually
how often the solids from the lagoon are removed for land application	once a year	once a year	once a year	once every three years	once every 2 years	once a year	once a year	once a year	once every 3 years
what happened to the manure from feeding lanes prior to IEUA's digester project	scraped every day and piled in corrals to dry	scraped every day and piled in corrals to dry	scraped every other day and piled in corrals to dry	scraped ever other day and piled in corrals to dry	scraped 3 times a week and piled in corrals to dry	scraped 3 times a week and piled in corrals to dry	scraped once a week into a manure pit	scraped every other day and piled in corrals to dry	scraped every day and piled in corrals to dry
what happens to manure from the milk parlor?	applied to pasture	applied to pasture	applied to settling basins	applied to pasture	pumped into storage pond	applied to pasture	applied to pasture	applied to pasture	applied to pasture
4 What part of the population of the dairy cows contributes manure to the digester									
percentage of total manure does the digester receive	40	40	40	60	50	50	90	40	60
what age groups are not included	heifers	heifers, calves					dry cows	heifers, calves	heifers, calves

APPENDIX B
VERIFICATION STATEMENT
FROM ERT

Name:	**Inland Empire Utility Agency (IEUA)**
Contacts:	**Richard Atwater**
Prepared by:	**Wiley Barbour, ERT**
Emissions Model	**IEUA Digester Model 2004 (02-10-06)**
MRV Protocol:	**Inland MRV Protocol (02-10-06)**

Summary

Based on its review, ERT has verified the information submitted by IEUA as being consistent with the attached monitoring, reporting, and verification protocol. ERT has registered a total of 8,008 metric tons of CO_2 equivalent emission reductions in 2003 and 5,825 tons of CO_2-e reductions in 2004, conditioned on the following findings and adjustments.

Key Findings*

Project Boundaries & Dates:	The project boundaries are consistent with those described in the MRV Protocol. The project dates associated with the emission reductions verified in this statement are 1 January 2003 through 31 December 2004.
Additionality & Leakage:	The emission reductions were verified to be additional, given existing regulatory requirements. No leakage of emissions outside the project boundaries was identified.
Baseline:	The baseline is unmitigated release of all air pollutants, both from the local dairies where manure was stockpiled and stored in lagoons, and from agricultural fields where manure was land applied.
Monitoring, Data Collection, & Methodology:	In general, procedures were in keeping with the MRV protocol. The following deviations were determined to be acceptable. Measurements of biogas characteristics (composition, methane content, sulfur content, heat content) are taken sporadically by IEUA and contractors. A more systematic and regular testing procedure would enhance data quality. Incoming honey vacs and transfer containers delivering manure to the digester are weighed on a tipping scale at RP-5. Also, measurements of total solids and volatile solids are taken at RP-5. There is no scale at RP-1 requiring an estimation of weight based on the assumption that density is identical to loads received at RP-5. Although this is likely to be an accurate assumption a scale at RP-1 would enhance data quality. Measurements of TS and VS at RP-1 are taken after water is added to achieve desired dilution. This invalidates the data for use in the baseline calculations, requiring an assumption that solids content of undiluted loads at RP-1 have identical TS and VS properties as manure received at RP-5. Again, this is unlikely to cause a bias in the data. The efficiency of methane destruction in the flare was based on typical flare manufacturer's guaranteed value of 98 percent, which is also supported by the default

	value in EPA's AP-42 volume.
Quality Control, Reporting, Documentation, & Uncertainties:	Quality control, reporting, and documentation procedures followed were in keeping with the MRV protocol. Although the methane content measurements were only taken sporadically, relatively low variability was observed between measurements.

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Incremental Account Adjustment

Valid as of:	**24 January 2006**
Registered reductions (metric tons of CO_2-equivalents):	**5,825**
Vintage Year(s):	**2004**
ERT Serial Numbers:	

Attachments/Exhibits

Special Notes

Note that the registration of the project reduction at IEUA is performed in the context of ongoing efforts at IEUA to complete a corporate-wide inventory and register entity wide emissions with ERT.

*** Disclaimer:** While ERT believes that all allocations in its GHG Registry® result from a true and fair representation of participants' emissions performance, ERT assumes no liability for the allocations in the GHG Registry® or the uses to which they are put. Use of the GHG Registry® is governed under the terms and conditions of the GHG Registry® user agreement.

Environmental Resoures Trust, Inc.
1612 K St., NW Suite 1400
Washington, D.C. 2006
Tel: 202 785 8577
Fax: 785 2739
www.ert.net
www.ecoregistry.org

APPENDIX C
ATTESTATION STATEMENT
FROM IEUA

Attestation Statement

Reporting Entity: Inland Empire Utilities Agency (IEUA)
Reporting Time period: 2004

To Environmental Resources Trust, Inc:

As an officer of the Inland Empire Utilities Agency, I hereby certify that the operational data provided to document the emission reductions and renewable energy generation achieved in connection with operation of anaerobic digesters at RP-1 and RP-5 have been collected and reported to ERT in accordance with the methods and procedures described in the Monitoring, Reporting, and Verification Guideline, and are a true representation of the actual performance of the project.

VS.IEUA.2004.2
Verification Statement Reference Number

____
Name

____
Title

____
Signature Date

APPENDIX D
DOCUMENTATION FOR EMISSION FACTORS USED

List of Emission Sources

Row	Reference #	Emission Source Category Description	Contains TAC/ODC
1	B1-1	1. Boiler,6. Digester Gas (mmscf)	Yes
2	B1-2	1. Boiler,1. Natural Gas (mmscf)	Yes
3	B1-3	1. Boiler,6. Digester Gas (mmscf)	Yes
4	B1-4	1. Boiler,1. Natural Gas (mmscf)	Yes
5	B1-5	6. Flare (Non-Refinery),6. Digester Gas (mmscf)	Yes
6	B1-6	6. Flare (Non-Refinery),2. LPG, Propane, Butane (1000 gals)	Yes
7	B1U-1	5. Heater,1. Natural Gas (mmscf)	Yes
8	B2-1	11. Stationary I.C. Engines,6. Digester Gas (mmscf)	Yes
9	B2-2	11. Stationary I.C. Engines,1. Natural Gas (mmscf)	Yes
10	B2-3	11. Stationary I.C. Engines,6. Digester Gas (mmscf)	Yes
11	B2-4	11. Stationary I.C. Engines,1. Natural Gas (mmscf)	Yes
12	B2-5	11. Stationary I.C. Engines,6. Digester Gas (mmscf)	Yes
13	B2-6	11. Stationary I.C. Engines,1. Natural Gas (mmscf)	Yes
14	B2-7	11. Stationary I.C. Engines,3. Diesel/Distillate Oil (1000 gals)	Yes
15	B2-8	11. Stationary I.C. Engines,3. Diesel/Distillate Oil (1000 gals)	Yes
16	B2-9	11. Stationary I.C. Engines,3. Diesel/Distillate Oil (1000 gals)	Yes
17	B2-10	11. Stationary I.C. Engines,3. Diesel/Distillate Oil (1000 gals)	Yes
18	B2-11	12. Turbines,6. Digester Gas (mmscf)	Yes
19	B3-1	Material 120-Primer	No
20	B3-2	Material 112-Paint	No
21	B3-3	Material 120-Primer	No
22	B3-4	Material 112-Paint	No
23	B3-5	Material 120-Primer	No
24	B3-6	Material 112-Paint	No
25	B4-1	Activity Code-07. Sewage and waste water treatment	Yes
26	B4U-1	Activity Code-2B. Diesel storage and dispensing	No
27	B4U-2	Activity Code-2B. Diesel storage and dispensing	No
28	B4U-3	Activity Code-2B. Diesel storage and dispensing	No
29			

Form ' B1 AQMD 2002-2003 AER

Permitted Annual Emissions from Fuel Combustion in Boilers, Ovens, Furnaces, and Heaters

Row	Equipment Code	Fuel Code	Annual Fuel Usage	Organic Gases Emission Factor	Organic Gases Emission	Methane Emission Factor	Methane Emission	Nitrogen Oxides Emission Factor	Nitrogen Oxides Emission	Sulfur Oxides Emission Factor	Sulfur Oxides Emission	Carbon Monoxide Emission Factor	Carbon Monoxide Emission	PM10 Particulate Matter Emission Factor	Particulate Matter Emission	Use Default Emission Factor
1	1. Boiler	6. Digester Gas (mmscf)	10.09	2.70	27.24			24.57	247.91	16.00	161.44	1.74	17.56	5.00	50.45	No
2	1. Boiler	1. Natural Gas (mmscf)	22.23	5.50	122.27	2.30	51.13	39.18	870.97	0.60	13.34	2.38	52.91	7.60	168.95	No
3	1. Boiler	6. Digester Gas (mmscf)	16.45	2.70	44.42			24.61	404.83	16.00	263.20	1.75	28.79	5.00	82.25	No
4	1. Boiler	1. Natural Gas (mmscf)	23.99	5.50	131.95	2.30	55.18	39.95	958.40	0.60	14.39	2.43	58.30	7.60	182.32	No
5	6. Flare (Non-Refinery)	6. Digester Gas (mmscf)	13.55	2.70	36.59			36.00	487.80	16.00	216.80	20.00	271.00	5.00	67.75	No
6	6. Flare (Non-Refinery)	2. LPG, Propane, Butane (1000 gals)	7.06	0.26	1.84	0.28	1.98	12.80	90.37	4.60	32.48	3.20	22.59	0.28	1.98	Yes
7																
8																
9																
10																
TOTAL																
lbs					364.31		108.29		3060.28		701.65		451.15		553.70	
tons					0.18		0.05		1.53		0.35		0.23		0.28	

Organic Gases Emission	Methane Emission	Nitrogen Oxides Emission	Sulfur Oxides Emission	Carbon Monoxide Emission	Particulate Matter Emission
364.31 lbs	108.29 lbs	3060.28 lbs	701.65 lbs	451.15 lbs	553.70 lbs
0.18 tons	0.05 tons	1.53 tons	0.35 tons	0.23 tons	0.28 tons

Permitted Annual Emissions from Fuel Combustion - Internal Combustion Engines and Turbines

Row	Equipment Code	Fuel Code	Annual Fuel Usage	Organic Gases Emission Factor	Organic Gases Emission	Methane Emission Factor	Methane Emission	Nitrogen Oxides Emission Factor	Nitrogen Oxides Emission	Sulfur Oxides Emission Factor	Sulfur Oxides Emission	Carbon Monoxide Emission Factor	Carbon Monoxide Emission	Particulate Matter Emission Factor	Particulate Matter Emission	Use Default Emission Factor
1	11. Stationary I.C. Engines	6. Digester Gas (mmscf)	215.80	16.06	3,465.75			22.78	4,915.92	10.42	2,248.64	334.34	72,150.57	7.30	1,575.34	No
2	11. Stationary I.C. Engines	1. Natural Gas (mmscf)	57.21	65.93	3,771.86			90.65	5,186.09	0.24	13.73	672.40	38,468.00	6.74	385.60	No
3	11. Stationary I.C. Engines	6. Digester Gas (mmscf)	213.25	12.22	2,605.92			27.94	5,958.21	10.42	2,222.07	216.80	46,232.60	7.28	1,552.46	No
4	11. Stationary I.C. Engines	1. Natural Gas (mmscf)	57.09	16.08	918.01			80.41	4,590.61	0.24	13.70	458.15	26,155.78	6.73	384.22	No
5	11. Stationary I.C. Engines	6. Digester Gas (mmscf)	0.00	26.32	0.00			44.58	0.00	3.90	0.00	425.93	0.00	7.50	0.00	No
6	11. Stationary I.C. Engines	1. Natural Gas (mmscf)	0.00	120.36	0.00			863.94	0.00	0.60	0.00	568.14	0.00	0.08	0.00	No
7	11. Stationary I.C. Engines	3. Diesel/Distillate Oil (1000 gals)	0.12	37.50	4.50	0.00	0.00	469.00	56.28	7.10	0.85	102.00	12.24	33.50	4.02	Yes
8	11. Stationary I.C. Engines	3. Diesel/Distillate Oil (1000 gals)	0.06	37.50	2.25	0.00	0.00	469.00	28.14	7.10	0.43	102.00	6.12	33.50	2.01	Yes
9	11. Stationary I.C. Engines	3. Diesel/Distillate Oil (1000 gals)	0.07	37.50	2.63	0.00	0.00	469.00	32.83	7.10	0.50	102.00	7.14	33.50	2.35	Yes
10	11. Stationary I.C. Engines	3. Diesel/Distillate Oil (1000 gals)	0.03	37.50	1.13	0.00	0.00	469.00	14.07	7.10	0.21	102.00	3.06	33.50	1.01	Yes
11	12. Turbines	6. Digester Gas (mmscf)	3.66	16.06	58.78			22.78	83.37	10.42	38.14	334.34	1,223.68	7.30	26.72	No
12																
TOTAL																
lbs					10830.83		0.00		20865.52		1538.27		184259.19		3933.73	
tons					5.42		0.00		10.43		2.27		92.13		1.97	

APPENDIX A - DEFAULT EMISSION FACTORS FOR COMBUSTION EQUIPMENT (CRITERIA AND TOXICS)

Table 1
Default Emission Factors for External Combustion Equipment for Forms B1 and B1U

Fuel Type (fuel unit)	Organic Gases (lb/unit)	Methane (lb/unit)	Nitrogen Oxides (lb/unit)	Sulfur Oxides (lb/unit)	Carbon Monoxide (lb/unit)	Particulate Matter (lb/unit)
Natural Gas (mmscf) / Boilers Only	5.50	2.30	100.00	0.60	84.00	7.60
Natural Gas (mmscf) / Other Equipment	7.00	2.30	130.00	0.83	35.00	7.50
LPG, Propane, Butane (1000 gal.)	0.26	0.28	12.80	4.60	3.20	0.28
Diesel/Distillate Oil (1000 gal.)	1.32	0.05	20.00	7.10	5.00	2.00

Table 2
Default Emission Factors for Internal Combustion Engines for Forms B2 and B2U

Fuel Type (fuel unit)	Organic Gases (lb/unit)	Methane (lb/unit)	Nitrogen Oxides (lb/unit)	Sulfur Oxides (lb/unit)	Carbon Monoxide (lb/unit)	Particulate Matter (lb/unit)
Natural gas (mmscf)	280.00	1,120.00	3,400.00	0.60	430.00	----
LPG, Propane, Butane (1000 gal.)	83.00	----	139.00	0.35	129.00	5.00
Diesel/Distillate Oil (1000 gal.)	37.50	----	469.00	7.10	102.00	33.50
Gasoline (1000 gal.)	206.00	----	102.00	5.30	3,940.00	6.50

Table 3
Rule-Based Emission Factors for Combustion Equipment for Forms B1 and B2

(For Equipment in Compliance with Rule Limits)

Fuel Type (fuel unit)	Nitrogen Oxides (lb/fuel unit)
A) E.F. based on Rule 1146 for Form B1	
Natural Gas (mmscf)	49.80
LPG, Propane, Butane (1000 gal.)	4.50
B) E.F. based on Rule 1146.1/1146.2 for Form B1	
Natural Gas (mmscf)	37.40
LPG, Propane, Butane (1000 gal.)	3.40
C) E.F. based on Rule 1110.2 for Form B2 (Stationary ICEs only)	
Natural gas (mmscf)	238.70
LPG, Propane, Butane (1000 gallons)	15.30
Diesel/Distillate Oil (1000 gallons)	33.40
Gasoline (1000 gallons)	21.50

APPENDIX E
RENEWABLE ENERGY GENERATION DATA FOR THE IEUA ANAEROBIC DIGESTER PROJECT

Total power generation from digester gas in the year 2004

Facility	Total Dgas from Manure and food waste	Dgas Manure	Dgas Food Waste	Manure Dgas to Generator	Ren Energy Dgas
	cu ft	cu ft	cu ft	cu ft	kWh
RP-1	41,194,300	41,194,300	-	32,442,575	1,368,885
RP-5	38,082,258	28,666,354	9,415,904	15,948,809	672,946
Totals	79,276,558	69,860,654	9,415,904	48,391,384	2,041,831